GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

MINISTRY OF WATER RESOURCES

DEPARTMENT OF BANGLADESH HAOR & WETLANDS DEVELOPEMENT

CLASSIFICATION OF WETLANDS OF BANGLADESH

Volume 1: Main Report

December 2016

PROSOIL FOUNDATION CONSULTANT
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November 21, 2016

Mr. Md. Majibur Rahman
Director General
Department of Bangladesh Haor & Wetlands Development
72 Green Road, Dhaka – 1215

Subject: Submission of Final Report of the project 'Classification of Wetlands of Bangladesh'

Dear Sir,

It is our pleasure to submit herewith the Final Report of the project 'Classification of Wetlands of Bangladesh'. It may be noted that the Mid Term Report of the project was submitted on 31st July, 2016. A workshop was held on the report on 22nd October, 2016. The comments/suggestions and feedback received from the Technical Committee, different stakeholders/organizations and the workshop were reviewed critically and incorporated in this report.

On behalf of the Prosoil Foundation Consultant and the study team, we like to take this opportunity to thank the DBHWD for their useful guidance and strong support.

We believe that the proposed classification system of wetlands will provide useful directions for future studies regarding protection and restoration of wetlands of Bangladesh.

With assurance of best cooperation,

Md. Shamsul Islam

Engr. Md. Shamsul Islam
Chief Executive
Prosoil Foundation Consultant

H.S. Mozaddad Faruque
Team Leader
Prosoil Foundation Consultant

Preface

Wetlands are the most precious gift of nature. They are habitat of rich biodiversity. They are important from the considerations of their ecological functions, scenic beauty and economic values.

In Bangladesh, rivers, haors, floodplains, beels, jheels, ponds, dighis, low land areas etc. are generally perceived as wetlands. The Ramsar Convention (1971) has defined wetlands as *'areas of marsh, fen, peat land, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters.'* Moreover, internationally important wetlands *"may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands".* The lakes and rivers are understood to be covered by the Ramsar definition of wetlands in their entirety regardless of their depth.

In this study, the Ramsar definition of wetland has been considered. The classification has been made on the overall Ramsar Classification framework, with some modifications considering the local context of Bangladesh.

Wetlands are most vulnerable from both over-exploitations for economic gains and degradation of wetland environment. The classification of wetlands helps to identify and categorize each wetland in a country. The classification system provides the necessary information and parameters of wetland, so that conservation and restoration processes can be taken up effectively.

Bangladesh attaches much importance on the conservation/protection of wetlands. In this regard, GoB has declared 3 wetlands as Ramsar sites namely Tanguar Haor, Hakaluki Haor and Sundarbans. Moreover, GoB has declared a number of national policies and plans for development and conservation of wetlands as well as enacted several Acts and Rules.

The primary objective of this report is to prepare a wetland classification system for Bangladesh within the broad framework of Ramsar Classification System. Other objectives include preparation of maps for identifying wetlands and preparing lists of major wetlands in Bangladesh.

The Mid Term Report on 'Classification of Wetlands of Bangladesh' was submitted to the DBHWD on 31st July, 2016. The Report has 6 volumes: one main volume and other 5 volumes containing 8 Annexures. The Annexures depict macro level identification of wetlands and important project documents, including comments and suggestions of stakeholders. The report gave an outline (TOC) of the draft Final Report. The Mid Term Report was circulated to the different stakeholders including the Technical Committee Members. A workshop was held on the Report on 22nd October, 2016.

The comments/suggestions and feedback received from the stakeholders/organizations were reviewed carefully and incorporated in the Final Report. The Final Report has 8 volumes, one main and 7 other having 10 Annexures. The following Annexures, submitted with the Mid Term Report have been updated/completed and considered as Annexures of the Final Report.

Annexure 1: Rivers of Bangladesh

Annexure 3: Maps of Wetlands of Bangladesh

Annexure 7: Feedback from the Stakeholders

Annexure 6 has been renamed as 'Biodiversity of Wetlands of Bangladesh'. Moreover, the following new Annexures have been included in this Final Report.

Annexure 6E: Animals of Tanguar Haor

Annexure 6F: Freshwater Fishes of Bangladesh

Annexure 9: Soil of Wetlands of Bangladesh

Annexure 10: Wetland Photo Gallery

All the other Annexures of the Mid Term Report are considered as the Annexures of this report.

The 2nd meeting of the Technical Committee was held on 29th November, 2016 to discuss the (draft) Final Report. The Report was **recommended for approval** by the Technical Committee.

The 1st meeting of the Steering Committee, chaired by Dr. Zafar Ahmed Khan, Senior Secretary, Ministry of Water Resources was held on 18th December, 2016. The Steering Committee **approved the Report**.

We acknowledge with great appreciation Ministry of Water Resources, GoB and the DBHWD for initiating the project and giving opportunities to M/s Prosoil Foundation

Consultant to carry out such a milestone research project. We are grateful to Mr. Anisul Islam Mahmud, Hon'ble Minister, Ministry of Water Resources, Mr. Muhammad Nazrul Islam, Bir Protik, Hon'ble State Minister, Ministry of Water Resources and Dr. Zafar Ahmed Khan, Senior Secretary, Ministry of Water Resources for their kind support and approval of the project.

The team deeply acknowledges the co-operation and guidance of the Technical Committee of the project. The team also acknowledges the 'Department of Bangladesh Haor and Wetlands Development' for initiating the project and helping us to prepare the Report. We acknowledge the Water Resources Planning Organization (WARPO) for providing data from the National Water Resources Database (NWRD). We acknowledge the support and co-operation received from the Center for Environmental and Geographic Information Services (CEGIS).

Satellite images were collected from Internet website of the United States Geologic Survey (USGS). We also deeply acknowledge their support.

We are thankful to Mr. Majibur Rahman, Director General, Department of Bangladesh Haor and Wetlands Development and Mrs. Afroza Moazzam, former Director General, Department of Bangladesh Haor and Wetlands Development for their active support and co-operation. We appreciate the co-operation of Mr. Md. Nazmul Ahsan, Project Director, Department of Bangladesh Haor and Wetlands Development and Md. Nurul Amin, Director (Admin and Finance), Department of Bangladesh Haor and Wetlands Development. We would also like to thank Mrs. Fahmida Akhtar, PSO, Computer and Information, WARPO for helping us with all data affairs.

We also thank the local people, particularly of the Haor and coastal regions who in various ways helped the study team for better understanding of the conditions and challenges of the study area as well as acquiring data on flora and fauna of wetlands.

H.S. Mozaddad Faruque
Team Leader

Classification of Wetlands of Bangladesh

Final Report

The Final Report on 'Classification of Wetlands of Bangladesh', submitted in November, 2016 contains the following volumes:

Volume 1: Main Report

Volume 2: Annexure 1: Rivers of Bangladesh

Volume 3: Annexure 2: Haors of Bangladesh

Volume 4: Annexure 3: Maps of Wetlands of Bangladesh

Volume 5: Annexure 4: Beels of Bangladesh

Annexure 5: Reversible Wetlands

5A: List of Polders of Bangladesh

5B: List of FCD projects of Bangladesh

Annexure 6: Biodiversity of Wetlands of Bangladesh

6A: Plants of Inland Wetlands

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6C: Plants of Tanguar Haor

6D: Birds of Tanguar Haor

6E: Animals of Tanguar Haor

6F: Freshwater Fishes of Bangladesh

Volume 6: Supporting Documents

Annexure 7: Feedback from the Stakeholders

Annexure 8: TOR of the Project

Volume 7: Annexure 9: Soil Information of Wetlands of Bangladesh

Volume 8: Annexure 10: Wetland Photo Gallery

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GLOSSARY OF TERMS

Aman	Monsoon rice crop cultivated during July-August and harvested in mid-December.
Baor	Baors are oxbow lakes, formed by dead arms of rivers.
Beel	Beels are shallow lakes, which form in the lowest parts of the haor; sometimes these are perennial but more often seasonal. The water surfaces are contiguous with the ground water table and that beels are sustained from ground water to a large extent. Surface water does also collect in the beels during wet season, often spilling out of them into the main river system through khals.
Boro	Rice grown during the dry winter season, transplanted during January-mid February and harvested during mid-May.
District	An administrative unit comprising several upazila
Division	An administrative unit comprising several administrative districts
Ebb	The movement of the tide out to sea
Ecosystem services	The benefits that people receive from ecosystems, including provisioning, regulating, and cultural services
Estuary	An estuary is a partly enclosed coastal body of brackish water with one or more rivers or streams flowing into it, and with a free connection to the open sea.
Haor	Haors are bowl-shaped depressions of considerable aerial extent lying between natural levees of the rivers or high lands of the northeast region of Bangladesh. In most cases, haors have been formed as a result of peripheral faulting leading to the depression of the haor area. In the wet seasons, the haors are full of water, but during the dry seasons, these are dried up except for the beels.
Hijal	A type of water tolerant tree normally seen in the Haor areas.
Jheel	Jheel a local term representing a reach of an old river channel bed. Usually it appears as an oxbow lake.
Khal	Local name for a drainage channel connecting beels/rivers
Neap Tide	A tide just after the first or third quarters of the moon when there is least difference between high and low water
Ramsar	City in Iran, on the shores of the Caspian Sea, where the Convention on Wetlands was agreed on 2 February 1971; thus the Convention's informal nickname, "Ramsar Convention on Wetlands"
Ramsar Sites	Wetlands designated by the Contracting Parties for inclusion in the List of Wetlands of International Importance because they meet one or more of the Ramsar Criteria
Tide	Tides are the rise and fall of sea levels caused by the combined effects of the gravitational forces exerted by the Moon and the Sun and the rotation of the Earth.

ABBREVIATIONS AND ACRONYMS

BCAS	Bangladesh Centre for Advanced Studies
BDT	Bangladesh Taka
BHWDB	Bangladesh Haor and Wetlands Development Board (now renamed as Department of Bangladesh Haor and Wetland Development)
BWDB	Bangladesh Water Development Board
CEGIS	Center for Environment and Geographic Information Services
CREL	Climate-Resilient Ecosystems and Livelihoods
DBHWD	Department of Bangladesh Haor and Wetland Development
DAE	Department of Agricultural Extension
DoE	Department of Environment
DoF	Department of Forestry
DPHE	Department of Public Health Engineering
DPP	Development Project Pro forma
ECA	Ecologically Critical Area
EOI	Expression of Interest
FAP	Flood Action Plan
FC	Flood Control
FCD	Flood Control and Drainage
FCDI	Flood Control, Drainage and Irrigation
FPCO	Flood Plan Coordination Organization
GBM	Ganges-Brahmaputra-Meghna
GIS	Geographic Information System
GOB	Government of Bangladesh
GPS	Global Positioning System
ha	hectare
IMED	Implementation Monitoring and Evaluation Division (Ministry of Planning)
IUCN	International Union for Conservation of Nature

Km	Kilometer
MDG	Millennium Development Goal
MPO	Master Plan Organization
MoF	Ministry of Finance
MoWR	Ministry of Water Resources
NGO	Non-Governmental Organization
NWMP	National Water Management Plan
PD	Project Director
PSC	Project Steering Committee
PSP	Performa for Study/Survey Proposal
RFP	Request for Proposal
SDG	Sustainable Development Goal
SRDI	Soil Resource Development Institute
TBD	To be determined
TOR	Terms of Reference
WARPO	Water Resource Planning Organization
WMO	Water Management Organization

Executive summary

Wetlands are habitat of rich biodiversity. They are very important both from environmental and economic considerations. The importance of protection and safeguard of the wetlands have been mentioned in the Article 18.A of the Constitution of Bangladesh.

"The state shall endeavor to protect and improve the environment and to preserve and safeguard the natural resources, biodiversity, wetlands, forests and wild life for the present and future citizens." (Constitution of Bangladesh, Act 18.A)

Considering the importance of the wetlands and its conservation, Government of Bangladesh enacted several acts including Bangladesh Water Act, 2013, Bangladesh Environmental Protection Act, 1995, Bangladesh Environmental Protection Act (Revised), 2010, Water Reservoir Conservation Act, 2000, National River Protection Commission Act, 2013 etc. Moreover, policies regarding wetlands have been declared such as National Policies on Water, Environment, and Fisheries etc.

Bangladesh is a signatory to several international conventions and protocols such as the Ramsar Convention, MDG, and SDG and is committed to the development and conservation of the wetlands. For the purpose of conservation, protection and restoration of ecosystems of areas which due to degradation of environment have reached or threatened to be reached to 'critical state', Government of Bangladesh has declared them 'Ecologically Critical Areas (ECA)'. It may be noted that Bangladesh has 13 ECAs (up to 2015), all of which are wetlands.

In Bangladesh, rivers, floodplains, Haor, Baor, Beel, Jheel, ponds, low-lying areas, etc. are generally perceived as wetlands. The seasonally flooded inlands and the areas inundated due to tidal influence in the coastal area are also called wetlands. The **Bangladesh Water Act, 2013** defines wetland as *"Wetland means any land where water remains at the level of surface or close to it and which inundates with shallow water from time to time, and where grows such plants that may usually grow and survive in marsh land."* The **RAMSAR Convention (1971)** has defined wetlands as *'areas of marsh, fen, peat land, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters.'* In addition, for the purpose of protecting coherent sites, wetlands to

be included in the Ramsar List of internationally important wetlands *"may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands".* The lakes and rivers are understood to be covered by the Ramsar definition of wetlands in their entirety, regardless of their depth.

The primary objective of this report is to prepare a wetland classification system for Bangladesh within the broad framework of Ramsar Classification System. Other objectives include preparation of maps at macro level for identifying wetlands and preparing lists of major wetlands in Bangladesh. The classification system is expected to be used by government agencies, academia, non-government agencies, researchers, individuals, etc. as a national system. The whole report has 8 volumes: one main volume and other 7 volumes containing 10 Annexures. The Annexures depict macro level identification of wetlands and important project documents, including comments and suggestions of stakeholders.

Different publications, reports, documents, policies, acts etc. have been reviewed by the research team in order to develop the classification system of wetlands of Bangladesh. Some of the notable documents are,

- *The Ramsar Convention Manual, 1971*.
- *Classification of Wetlands and Deepwater Habitat of United States, FGDC, 2013*
- *The Vietnamese Wetlands Classification System, 2008*
- *National Wetland Atlas: Lakshadweep, Indian Space Research Organization, 2009*
- *Master Plan of Haor Areas, BHWDB, 2012*
- *National Water Policy of Bangladesh, 1999*
- *Coastal Zone Policy of Bangladesh, 2005*

The preliminary methodology was described in the Inception Report and was approved by the Technical Committee and the DBHWD. The same methodology has been followed with minor modification and adjustments in the preparation of both the Mid Term Report and the Final Report. Although the study is done mainly on data from secondary sources, some primary data such as aquatic plants, birds, photographs and soil types were collected from 64 districts. The primary data were collected for something close to spot checking. Data on soil parameters and flora have been presented as separate annexures (Annexure 9 and 6), in compliance with the decisions of the meeting of the project monitoring. The data lists of

aquatic plants, birds, soil types etc. have been collected from the relevant secondary sources. This has been analyzed and presented as separate annexures.

The physical geography of Bangladesh is varied and has two distinctive features: delta formed by the GBM river systems and small hilly region. In the context of physiography, the country may be classified into three distinct regions namely Floodplains, Terraces and Hills. The country has been tentatively divided into 30 agro ecological zones on the basis of physiography, soils land levels in relative to floodplains and agro-climatology. The rivers of the country can be categorized into four major systems namely:

1. Brahmaputra-Jamuna River System
2. Ganges-Padma River System
3. Surma-Meghna River System
4. Chittagong Region River System

The country can be divided into 7 soil tracts based on the geological origin; namely Madhupur Tract, Barind Tract, Teesta Silt, Brahmaputra Alluvium, Gangetic Alluvium, Coastal Saline Tract and Chittagong Hill Tract.

Considering the climate as the most active pedogenic factor, the country has been divided into three pedoclimatic zones namely; Humid, Semi-Humid and Feebli Arid. The single largest land use is agriculture. Arable land occupies about 9 million (M) ha (22 M acres), forest about 2.25 M ha (5.5 M acres) and settlement plus water bodies about 3 M ha (7.5 M acres) *(Brammer, 2004).* Climate of Bangladesh is tropic and humid. There are four prominent seasons Pre-monsoon (March to May), Monsoon (June to September), Post Monsoon (October to November) and Dry season (December to February). The possible impact of global warming and climate change on Bangladesh are:

i) A rise in sea level in the order of 300mm by the year 2030 and 700 mm by 2075. This suggests a rise of 250 mm by 2025, at the rate of 10 mm/year.
ii) A rise in monsoon season temperature of 0.7°C by 2030 and 1.1°C by 2050. Dry season temperatures would rise by 1.3°C by 2030 and 1.8°C by 2050.
iii) An increase in monsoon rainfall of about 10% by the year 2030 and 25% by 2050. Dry season rainfall is projected to reduce in the long term.

The wetland classification of Bangladesh is basically based on the Ramsar classification framework. However, some modifications have been made considering the conditions of Bangladesh. The classification system is particularly based on the central issue **Hydrological Considerations**.

In Bangladesh, embankments and allied structures have been constructed both at inland and at coastal zone for flood control purposes. The area thus protected from flood by embankments or polders are not being considered as wetlands any more. However, there remains great threat of breach or damage of the embankments due to natural hazards like cyclone or river erosion or other causes. If embankment breach occurs, the area will again be flooded regularly till repair or construction of new embankment is made. This indicates that the area once protected by the embankments or polders are vulnerable to become wetland again. Hence a terminology of **'Reversible Wetlands'** has been introduced. The Reversible Wetlands have been defined as the area which have been given flood protection and is vulnerable to become flooded if breach of embankment occurs or if the embankments, flood control/drainage etc. structures are withdrawn. It also includes environmentally degraded but restorable wetlands. The concept of the 'Reversible Wetlands' was discussed with the DBHWD. The DBHWD has endorsed the concept.

For the classification of wetlands of Bangladesh, a strategy for classification was formulated and was approved by the DBHWD. The Strategies of Classification of Wetlands of Bangladesh are:

1. Ramsar definition of wetland will be followed.
2. The classification will be based on the central issue of wetland concept i.e. hydrology.
3. The classification should be based on overall system of Ramsar classification of wetlands.
4. Country specific classification system, considering geographical and environmental situation will be developed within the broad framework of Ramsar.
5. While Ramsar classification system has 3 broad types, classification system of Bangladesh will have 4 types. One new type 'Reversible Wetland' will be considered in classification of wetlands of Bangladesh.

6. The plant and soil data which will be collected during the study will be recorded and presented in the annexures.
7. Each system except the 'Reversible Wetlands' system is divided into two classes; Permanent and Non-permanent.

Classification of Wetlands of Bangladesh, shown in Table 7.2, has categorized 4 systems, 2 classes and 30 types. The details of the classification system have been discussed in Chapter 7. The nomenclature of types has been done in such a way that it indicates the corresponding type of Ramsar Classification. For example, BA type; 'B' stands for Bangladesh, 'A' stands for 'A' type of Ramsar classification (which is *Permanent shallow marine waters in most cases less than six meters deep at low tide; includes sea bays and straits).*

The wetland classification system of Bangladesh has been compared with Ramsar, FGDC of USA, Vietnamese and Indian (NWIA) classification systems.

The major focus of the study was the classification of wetlands of Bangladesh. The definition of wetland in this classification does not cover the biological extent of wetland, as influenced by the hydrologic characteristics at each site. The detailed inventory of the wetlands was beyond the scope of the study. However, macro level inventories of major inland wetlands (Haors, Rivers, Beels, and Reversible Wetlands etc.) have been prepared and presented in Annexures. Brief description of some major wetlands have also been given as examples. The following Table shows the wetland types and some general examples of wetlands of Bangladesh.

Table 8.1: Examples of Wetland Types in Bangladesh

Systems	Classes	Types Symbols	Name of wetland types	Examples
Marine/Coastal Wetlands	Permanent	BA	Permanent shallow marine waters in most cases less than six meters deep at low tide; includes sea bays and straits	Entire coastal belt upto a depth of 6m
		BB	Marine subtidal aquatic beds; includes kelp beds, sea-grass beds, tropical marine meadows	Entire coastal belt and islands which remain inundated and where aquatic plants are grown
		BC	Coral Reefs	St. Martin's Island, some parts of Cox's Bazar
		BF	Estuarine waters; permanent water of estuaries and estuarine systems of deltas	Estuaries of Meghna and Karnaphuli, Shahbazpur Channel etc.
	Non-Permanent	BE	Sand, shingle or pebble shores; includes sand bars, spits and sandy islets; includes dune	Sea beaches of Bay of Bengal
		BG	Intertidal mud, sand or salt flats	Sea beaches of Teknaf, Cox's Bazar and other sea shores
		BI	Intertidal forested wetlands; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests	Sundarbans

(continued)

[Note 1:

***BX** – 'B' stands for Bangladesh, 'X' stands for corresponding X type of Ramsar wetland type*

Example:

***BA** – 'B' stands for Bangladesh, 'A' stands for Ramsar type (A: Permanent shallow marine waters in most cases less than six meters deep at low tide; includes sea bays and straits)*

***B1** – 'B' stands for Bangladesh, '1' stands for Ramsar type (1: Aquaculture (e.g., fish/shrimp) ponds)]*

Table 8.1: Examples of Wetland Types in Bangladesh (contd.)

Systems	Classes	Types Symbols	Name of wetland types	Examples
Inland Wetlands	Permanent	BL	Permanent inland deltas	Char lands of rivers
		BM	Permanent rivers/streams/creeks; includes waterfalls	Permanent rivers of Bangladesh, waterfalls etc.
		BO	Permanent freshwater lakes (over 8 ha); includes large oxbow lakes	Beels, Baors
		BTp	Permanent freshwater marshes/pools; ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season	Beels within haor areas
Inland Wetlands	Non-Permanent	BN	Seasonal/intermittent/irregular rivers/streams/creeks	Seasonal rivers of Bangladesh, hilly streams, springs etc.
		BP	Seasonal/intermittent freshwater lakes (over 8 ha); includes floodplain lakes	Haors, Beels
		BTs	Seasonal/intermittent freshwater marshes/pools on inorganic soils; includes sloughs, potholes, seasonally flooded meadows, sedge marshes	Lowland, potholes etc. within haor area
		BU	Non-forested peatlands; includes shrub or open bogs, swamps, fens	Peatlands within haor areas, beels of Satkhira, Khulna & Gopalganj
		BW	Shrub-dominated wetlands; shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils	Seen within haor area
		BXf	Freshwater, tree-dominated wetlands; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils	Seen within haor area
		BXp	Forested peatlands; peatswamp forests	Forested peatlands of lowlands of Satkhira, Khulna & Gopalganj

(continued)

[Note 1:

***BX** – 'B' stands for Bangladesh, 'X' stands for corresponding X type of Ramsar wetland type*

Example:

***BA** – 'B' stands for Bangladesh, 'A' stands for Ramsar type (A: Permanent shallow marine waters in most cases less than six meters deep at low tide; includes sea bays and straits)*

***B1** – 'B' stands for Bangladesh, '1' stands for Ramsar type (1: Aquaculture (e.g., fish/shrimp) ponds)]*

Table 8.1: Examples of Wetland Types in Bangladesh (contd.)

Systems	Classes	Types Symbols	Name of wetland types	Examples
Human-made Wetlands	Permanent	B1	Aquaculture (e.g., fish/shrimp) ponds	Dighi, ponds, shrimp ponds
		B2	Ponds; includes farm ponds, stock ponds, small tanks; (generally below 8 ha)	Small ponds, including ponds for fish culture
		B6	Water storage areas; reservoirs/barrages/dams/impoundments (generally over 8 ha)	Reservoir of Teesta & Kaptai, Dams of Muhuri & reservoirs of Magura etc.
		B8	Wastewater treatment areas; sewage farms, settling ponds, oxidation basins etc.	WWTP of Pagla (Dhaka WASA)
		B9	Canals and drainage channels, ditches	Madaripur Beel Route, Mongla-Ghashikhali Channel, Gab Khan Channel, Irrigation channels of BWDB, Teesta Irrigation Project
	Non-Permanent	B3	Irrigated land; includes irrigation channels and rice fields	Irrigation project areas of the BWDB
		B4	Seasonally flooded agricultural land (including intensively managed or grazed wet meadow or pasture)	Floodplains of the rivers
		B5	Salt exploitation sites; salt pans, saline etc.	Salt areas and salt cultivation areas of Teknaf and Barisal
		B7	Excavations; gravel/brick/clay pits; borrow pits, mining pools	Roadside borrow pits, Barapukuria Coal Mine etc.
Reversible Wetlands		Brvc	Coastal polders and embankments	139 coastal polders of the country
		Brvi	FCD and FCDI projects; flood protected inlands with embankments	All inland BWDB FCD & FCDI projects
		Brve	Environmentally degraded, but restorable wetlands	Polluted rivers, encroached rivers, khals, lowlands etc.

[Note 2:

***Brvc** – 'B' stands for Bangladesh, 'rv' stands for Reversible Wetlands, 'c' stands for Coastal Polders and embankments.*

***Brvi** – 'B' stands for Bangladesh, 'rv' stands for Reversible Wetlands, 'i' stands for FCD and FCDI projects; flood protected inlands with embankments.*

***Brve** – 'B' stands for Bangladesh, 'rv' stands for Reversible Wetlands, 'e' stands for Environmentally degraded, but restorable wetlands.]*

The Classification of Wetlands of Bangladesh has been designed for using over a broad geographic area all over Bangladesh by individuals and organizations with varied interests and objectives. Major recommendations of the study are:

- This classification system should be applied throughout Bangladesh, making it a national system.
- It is strongly recommended that, Govt. of Bangladesh take immediate steps to approve this classification system of wetlands of Bangladesh and issue directives so that this system is used by individuals/organizations throughout the country.
- Any new, updated, or revised mapping of wetlands of Bangladesh shall conform to this Wetlands Classification Standard.
- Study on micro-level inventory of each type of wetlands should be taken up.
- For carrying out such study, satellite images of finer resolution need to be collected. The DBHWD should immediately take up project on collection of satellite images both for monsoon and dry periods.
- Study on ecological characteristics of wetlands (type-wise) should be taken up.
- The DBHWD should initiate a programme for preparation of a video documentary on wetlands of Bangladesh according to the classification system.

1 INTRODUCTION

1.1 Background

Wetlands are precious gifts of nature. They are habitats of rich biodiversity. Life and livelihood of millions of people around the world are being supported by the wetlands. The area of wetlands is about 6.8 million sq. km, which is about 6% of the earth's land surface, and they are considered to be one of the most threatened natural ecosystems *(Matthew et al., 1987)*. The UN Millennium Ecosystem Assessment concluded that environmental degradation is more prominent within wetland systems than any other ecosystem on earth. *(Millennium Ecosystem Assessment, 2005)*

Traditionally, wetlands have been used for economic activities such as agriculture, fishery, navigation, forestry, hunting grounds and recreation etc. They also serve as a source of fuel, wood and construction materials.

The unique habitat type of wetlands provides the transition from water to terrestrial environment, has even more important functions– wetlands shelter a great number of globally endangered plant and animal species and they are extremely important to surface and groundwater purification and groundwater aquifer recharge. Wetlands also mitigate the negative consequences of floods and erosion. The most important functions of wetlands are:

- **Biodiversity protection:** Wetlands support a great diversity of species, many of which are unique and rare. Freshwater ecosystems cover only 1% of the Earth's surface but they hold more than 40% of the world's species and 12% of all animal species. Although they cover only 0.2% of the ocean floor, coral reefs may contain 25% of all marine species *(Matthew et al., 1987)*.
- **Water storage:** Water is stored in the soil or retained in the surface waters of lakes, marshes, rivers and beels etc.
- **Groundwater replenishment:** A portion of the water stored in wetlands filter into the ground and recharge underground aquifers (groundwater reservoirs).
- **Sediment retention:** By slowing down the velocity of runoff and flow of water, wetlands help in deposition of sediments carried by the water.

- **Retention of nutrients and other substances:** Wetland species (specially plants) effectively remove nutrients (mainly nitrogen and phosphorous) from agricultural sources but also from human wastes and industrial discharges.
- **Storehouses (sinks) of carbon:** Wetlands play at least two critical roles in mitigating the effects of climate change: one in the management of greenhouse gases (especially carbon dioxide, CO_2) and the other in physically buffering climate change impacts. *(Bergkamp, 2001)*

Wetlands in Bangladesh are under increasing stress due to the rapidly growing population, technological development, urbanization and economic growth. Developing a wetland classification system for the country is the first step for preparation of a detailed inventory of wetlands, in a scientific manner, to identify and categorize each wetland in the country. This can help the Government and policy makers to identify the vulnerable wetlands and the causes behind their deterioration. In turn, this can help the policy makers to come up with plans and policies for conservation and restoration of the wetlands. The importance of wetlands and its classification have been further discussed in Section 5.2 and 5.3 respectively.

In Bangladesh, rivers, floodplains, lakes, haors, baors, beels, jheels, ponds, low-lying areas, etc. are generally perceived as wetlands. The seasonally flooded inlands and the areas inundated due to tidal influence in the coastal area are also called wetlands.

The Bangladesh Water Act (2013) defines wetlands as: *"Wetland means any land where water remains at the level of surface or close to it and which inundates with shallow water from time to time, and where grows such plants that may usually grow and survive in marsh land."*

Ramsar Convention (1971) defines wetlands a little differently, which is: *"Wetlands are areas of marsh, fen, peat land, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters."*

In addition, for the purpose of protecting coherent sites, the Article 2.1 of Ramsar Convention provides that wetlands to be included in the Ramsar List of Internationally Important Wetlands: "*may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands".*

In addition, there are human-made wetlands. It is also to be noted that lakes and rivers are understood to be covered by the Ramsar definition of wetland, in their entirety, regardless of their depth *(Ramsar, 1971)*.

The Ramsar Convention was adopted in the Iranian city of Ramsar in 1971 and came into force in 1975. In 21 September 1992, Bangladesh entered the convention as a contracting party.

Following the recommendation/approval of the Technical Committee of this project, Ramsar definition of wetlands have been considered for this study.

In a broader sense, the wetlands may be of two types: Natural and Manmade. The Natural type includes Marine/Coastal Estuarine and Inland wetlands. The St. Martin's Island, the Sundarbans Mangrove Forest, etc. are examples of Marine/Coastal wetlands. The Inland wetlands include Rivers, Haors, Baors, Beels, Ponds etc. There are 405 Rivers *(BWDB, 2011)* and 373 Haors *(BHWDB, 2012)* in Bangladesh. It is reported that there are 6300 Beels within the Haors *(FAP 6, 1995)*. Moreover, there are Beels in the floodplains of the country. Kaptai Lake is an example of permanent Manmade wetlands. Irrigated areas, dighis, ponds, etc. are other examples of manmade wetlands.

National Water Management Plan (NWMP) has divided Bangladesh into 8 hydrological regions. The regions are: Southwest (SW), Northeast (NE), North Central (NC), Northwest (NW), South Central (SC), Southeast (SE), Eastern Hills (EH) and River and Estuary Region (RE). All the rivers of the country can be considered as "Inland Wetlands" whereas all estuaries are "Marine/ Coastal Wetlands".

The floodplains of Bangladesh are essentially wetlands. There are 4 main types of floodplains in Bangladesh and they are: river, piedmont, tidal and estuarine floodplains *(Brammer, 2012)*.

The wetland classification of Bangladesh is basically based on the Ramsar classification framework. However, some modifications have been made considering the conditions of Bangladesh. There are 9 specific criteria for the identification of internationally important wetlands by Ramsar Convention. The criteria are shown in Box 4.1. Considering these criteria, 3 sites in Bangladesh have been declared as Ramsar Sites, which are the **Sundarbans**, **Hakaluki Haor** and **Tanguar Haor**. There are certain types of wetlands, included in the "Ramsar Classification System for Wetland Type", that do not exist in

Bangladesh. For example, there is no Tundra or Alpine wetlands or Karst topography in Bangladesh. Hence the Ramsar classification types modified to some extent, have been considered for Bangladesh. Further discussion has been made in Chapter 7.

A number of documents and reports have been reviewed and studied by the team in order to understand the dynamics and complex nature of wetlands as well as the existing classification systems of different countries. These documents have helped the team to develop the classification system of wetlands of Bangladesh. The detailed review of 16 publications and documents have been given in Chapter 4. Moreover, the team consulted several other documents and journal publications. They have been included during citation and mentioned in the section 'References'.

1.2 Dynamics of Wetlands

Wetlands are very dynamic and complex in characteristics. They can produce more plant and animal life than woodlands or forests of the same size. Wetlands often undergo a variety of changes, both seasonally and from year to year. Some of the wetlands, such as rivers, lakes etc. usually contain water round the year. There exists a yearly flooding/lean period cycle for most of the rivers. The river flows and depth change drastically during the monsoon and dry periods. Some of the rivers even dry up during dry season. Most of the rivers of the country cause flooding during the monsoon.

Wetlands can go dry and then flood periodically and be used for agriculture during dry period and fisheries in the inundation period. Temporary and seasonally flooded wetlands do not contain water all year round. They go through a wet/dry cycle essential to their continued productivity and functioning. During dry times, some wetland plants are able to start growing.

In a very simplified way, the food chain of the wetlands is described as below:

Many of the wetland plants produce seeds, or tubers, that are eaten by water birds and other wildlife. When water returns, older plants that have died decompose quickly, releasing nutrients into the system. These nutrients feed algae, which in turn feed insects and other invertebrates. Invertebrates found in these wetlands are specially adapted to the wet/dry cycle. They reproduce quickly and in abundance once water returns. Wetland wildlife are well adapted to these changes.

The interaction of these natural processes make wetlands very productive. If some of these processes are altered; for example, by maintaining constant water levels, deforestation or encroachment, the natural wetland can begin to deteriorate. Other factors that can cause deterioration of wetland are influenced by people, such as permanent drainage, filling with soil, concrete or trash, diverting water or erosion etc.

As mentioned earlier, wetlands also provide a potential sink for atmospheric carbon. But, if not managed properly, they may become a source of greenhouse gases. Wetlands are dynamic ecosystem, where significant quantities of carbon from both wetland and non-wetland sources may also be trapped and stored in wetland sediments. In the mechanism of photosynthesis, wetland trees and other plants convert atmospheric carbon dioxide into biomass. Hence carbon may be temporarily stored in wetlands as trees and plants and the living material which feed upon them, and also in detritus including fallen plants. *(Lagrange, 2005)*

1.3 Objectives

The objectives as mentioned in the approved Performa for Study/Survey Proposal (PSP) of this project are quoted below:

"1. To classify the wetlands of Bangladesh on the basis of their hydrological and ecological functions and land type concept;
2. *To locate all the wetlands in map by types;*
3. *To gather, analyze, and present information that will aid decision makers in the identification and resolution of problems associated with major wetlands use changes; and*
4. *To provide better ecological information for organizations related to wetlands, such as those relating to wetlands development."*

Broad objective of the research is to enhance knowledge base of the country in general and to strengthen Department of Haor and Wetlands Development in its role as a primary source of information on wetlands resources in particular.

- The primary objective of this report is to prepare a wetland classification system for Bangladesh within the broad framework of Ramsar Classification System.
- Preparation of maps for identifying wetlands (at macro level)

- Preparation of lists of major wetlands in Bangladesh such as Rivers, Haors, Beels, etc. at macro level.

1.4 Scope

The wetland classification system of Bangladesh is particularly based on hydrological considerations and wetland plants. The classification system is expected to be used by government agencies, academia, non-government agencies, researchers, individuals, etc. as a national system. The details of the classification system have been given in Chapter 7.

1.5 Limitations

This wetland classification system consists of systems, classes, names and types. No attempt has been made to make any inventory of the wetlands as it is beyond the scope of TOR of the project. The constraints and limitations of the project as also mentioned in the Inception Report are:

"1. Due to the limitation of time and financial resources, most of the study has been carried out using data of secondary sources. However, some surveys have been carried out to analyze and substantiate the results.
2. The study produces macro level inventory of wetlands according to its classification.
3. Satellite images of finer resolution of the whole country is required for GIS mapping. The budget does not include the cost of this images.
4. Historical or potentially restorable wetlands will not be classified. (not in TOR)
5. No attempt has been made to define the jurisdictional boundaries of national agencies over the wetlands. (not in TOR)"

1.6 Comparison with Other Standards

The wetland classification system of Bangladesh is based on Ramsar standard. It has been compared with Ramsar, FGDC of USA and other country specific classification systems such as Vietnam and India, the details of which has been given in Chapter 7. Both the Vietnamese and Indian classification systems can be considered as country specific modified Ramsar classification systems. The maps in this report have been prepared following the 'Wetlands Mapping Standard, FGDC-STD-015-2009'. Government of Bangladesh (GoB) endorsed maps have been used. GoB endorsed district, upazila, international boundaries, geographical features and other attributes have been used for preparation of the maps.

2 METHODOLOGY

The methodology of the study was described in the Inception Report and was approved by the Technical Committee and the DBHWD. The methodology that was discussed in the Mid Term report is almost the same as that of the Inception Report, with slight modifications and adjustments.

2.1 Collection of Primary Data

List of aquatic plants, birds, photographs and soil types have been collected from 64 districts by the enumerators. Data were collected in the formats prepared in consultation with the DBHWD.

Field visit were made by the senior consultants from time to time to ensure the quality of collection of sample data.

2.2 Collection of Secondary Data

The data lists of aquatic plants, birds, aquatic animals, soil types etc. have been collected from the relevant secondary sources. This will also be analyzed and categorized similar to that of primary data. Details of secondary data and their sources have been discussed in chapter 6.

2.3 Analysis and Validation of Primary and Secondary Data

Both the primary and secondary data have been analyzed as mentioned above. During field visits and collection of primary data, ground truthing or validation of the samples of secondary data were conducted. Moreover, the collected samples of vegetation and photographs of aquatic vegetation/aquatic animals/ birds etc. have been identified with the help of the *Encyclopedia of Flora and Fauna of Bangladesh (Asiatic Society, 2008)* and through matching with photographs collected from internet published documents.

2.4 Classification of Wetlands

The following classification systems of wetlands were studied:

1. Ramsar Classification System of Wetlands
2. FGDC Classification System of Wetlands and Deep Water Habitat of the USA

3. Wetlands Classification System of Vietnam
4. Wetland Classification System of India

A strategy was formulated for the classification of wetlands of Bangladesh. The draft strategy calls for country specific system, considering its geographical location and environmental condition, with hydrology as the central issue and within the broad framework of Ramsar method. The strategy was discussed with the DBHWD. With the agreed strategy, the classification of wetlands of Bangladesh was carried out. Some maps are being prepared showing different attributes. The details are discussed in Chapter 7.

2.5 Preparation of Report

The list of reports which are being subsequently prepared and submitted to the DBHWD are:

1. Field Visit Reports
2. Draft Inception Report
3. Inception Report
4. Status Reports
5. Mid Term Report
6. (draft) Final Report
7. Final Report

The Mid Term Report has been distributed to the stakeholders. With the feedback received from the stakeholders and their incorporation, the Final Report has been prepared.

The Mid Term report has been discussed in a workshop held on 22th October, 2016. Incorporating the feedback for the workshop and comments from the DBHWD, the report has been finalized.

The Final Report contains the complete methodology and classification of wetlands. It is expected that the Department of Bangladesh Haor and Wetland Development will post this report in the website for public accessibility.

The methodology which has been adopted for conducting the study is shown in the flow chart is given in Fig. 2.1:

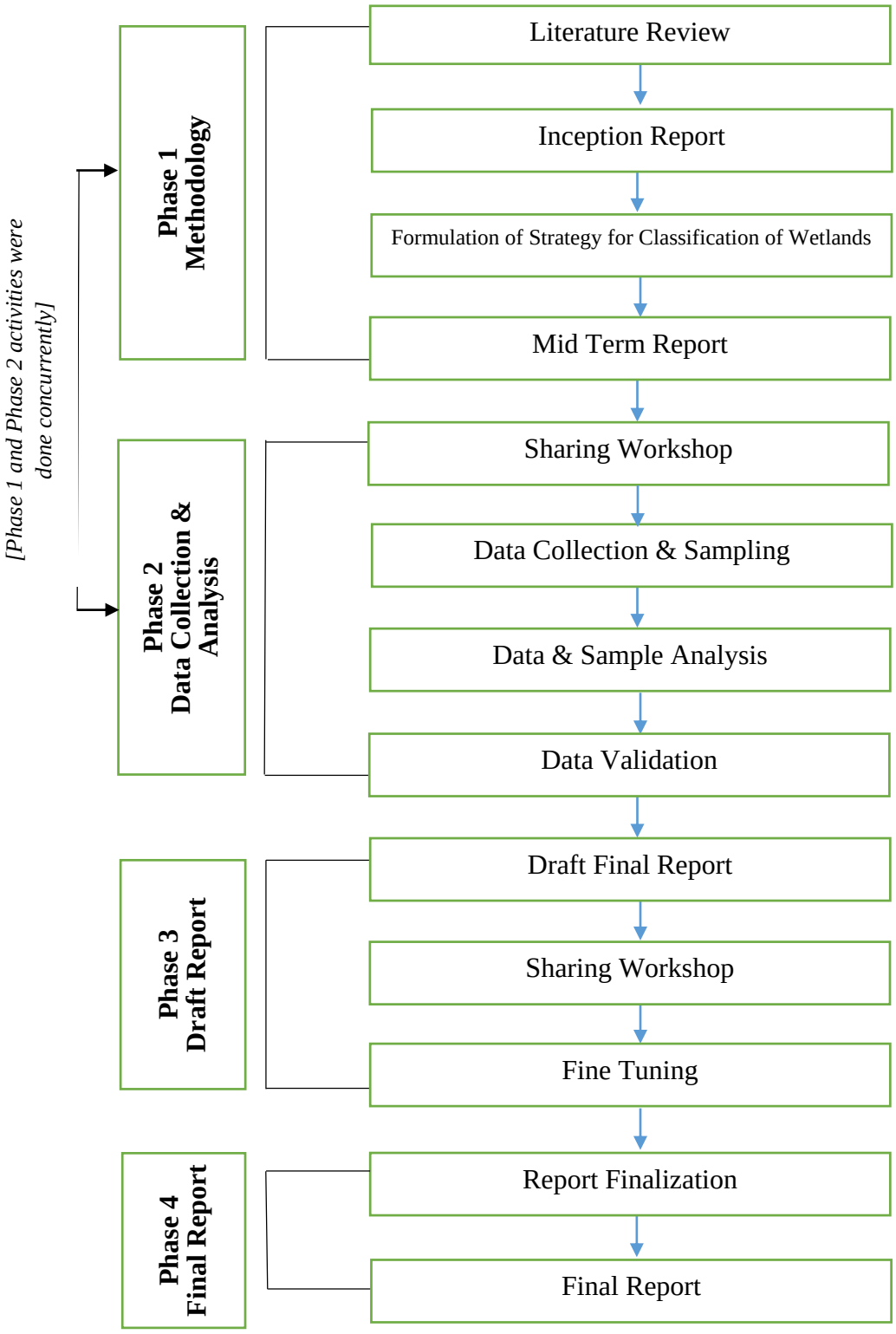


Figure 2.1: Flowchart of methodology of classification

3 SETTING OF BANGLADESH

3.1 Physiographical Setting

3.1.1 Geographical Setting

Bangladesh covers an area of 147,570 km^2 and lies between 20°34´N to 26°38´N latitude and from 88°01´E to 92°41´E longitude. The Indian States of West Bengal are in the west and north, Assam and Meghalaya are in the north and Tripura is in the east border of Bangladesh. Myanmar forms border in the South Eastern part. The South of the country is enclosed by the Bay of Bengal with a coastline more than 580 km. The territorial waters of Bangladesh extend 12 nautical miles and the area of the high seas extending to 200 nautical miles measured from the base lines constitutes the economic zone of the country (*Banglapedia, 2003*). The southwestern part of the country is covered by Sundarbans, largest mangrove forest of the world.

The physical geography of Bangladesh is varied and has an area characterized by two distinctive features: areas lies within the broad delta formed by the Ganges, Brahmaputra and Meghna rivers which are exceedingly flat, low-lying, and subject to annual flooding, and a small hilly region crossed by swiftly flowing rivers. Roughly 80% of the landmass is made up of fertile alluvial lowland called the Bangladesh Plain. The only exceptions to Bangladesh's low elevations are the Chittagong Hills in the southeast, the Low Hills of Sylhet in the northeast, and highlands in the north and northwest.

3.1.2 Physiography of Bangladesh

The term ‘Physiography’ was restricted to the part of physical geography that is involved with the description and origin of landforms. With about half of its surface below the 10m contour line, Bangladesh is located at the lowermost reaches of three mighty river systems - the Ganges-Padma River System, the Brahmaputra-Jamuna River System and the Surma-Meghna River System.

Quaternary sediments, deposited mainly by the Ganges, Brahmaputra (Jamuna) and Meghna rivers and their numerous distributaries, cover about three-quarters of Bangladesh. The physiography and the drainage pattern of the vast alluvial plains in the central, northern and western regions have gone under considerable alterations in recent times. The deposition of

Quaternary sediments was influenced and controlled by structural activities. The eastward shift of the Ganges and Teesta as well as the significant westward shift of the Brahmaputra during the last 200 years give evidence of epeirogenic movements even in recent days. Hillocks and hills are confined to a narrow strip along the southern spur of the Shillong Plateau, to the eastern and southern portions of the Sylhet district, and to the Chittagong Hill Tracts (CHT) in the southeast of the country bordering upon India (Tripura and Mizoram) and Myanmar.

In the context of physiography, Bangladesh may be classified into three distinct regions which are **Floodplains, Terraces, and Hills**, each having distinguishing characteristics of its own. Major sub-regions and units are:

i) Floodplains:

1. Old Himalayan Piedmont Plain
2. Teesta Floodplain
3. Old Brahmaputra Floodplain
4. Jamuna (Young Brahmaputra) Floodplain
5. Haor Basin
6. Surma-Kushiyara Floodplain
7. Meghna Floodplain
    a. Middle Meghna Floodplain
    b. Lower Meghna Floodplain
    c. Old Meghna Estuarine Floodplain
    d. Young Meghna Estuarine Floodplain
8. Ganges River Floodplain
9. Ganges Tidal Floodplain
10. Sundarbans
11. Lower Atrai Basin
12. Arial Beel
13. Gopalganj-Khulna Peat Basin
14. Chittagong Coastal Plain
15. Northern and Eastern Piedmont Plain

ii) Terraces

16. Pleistocene Uplands
    a. Barind Tract
    b. Madhupur Tract and
    c. Tippera Surface

iii) Hills

17. Northern and Eastern Hills
    a. Low Hill Ranges (Dupi Tila and Dihing Formations)
    b. High Hill or Mountain Ranges (Surma and Tipam Formations).

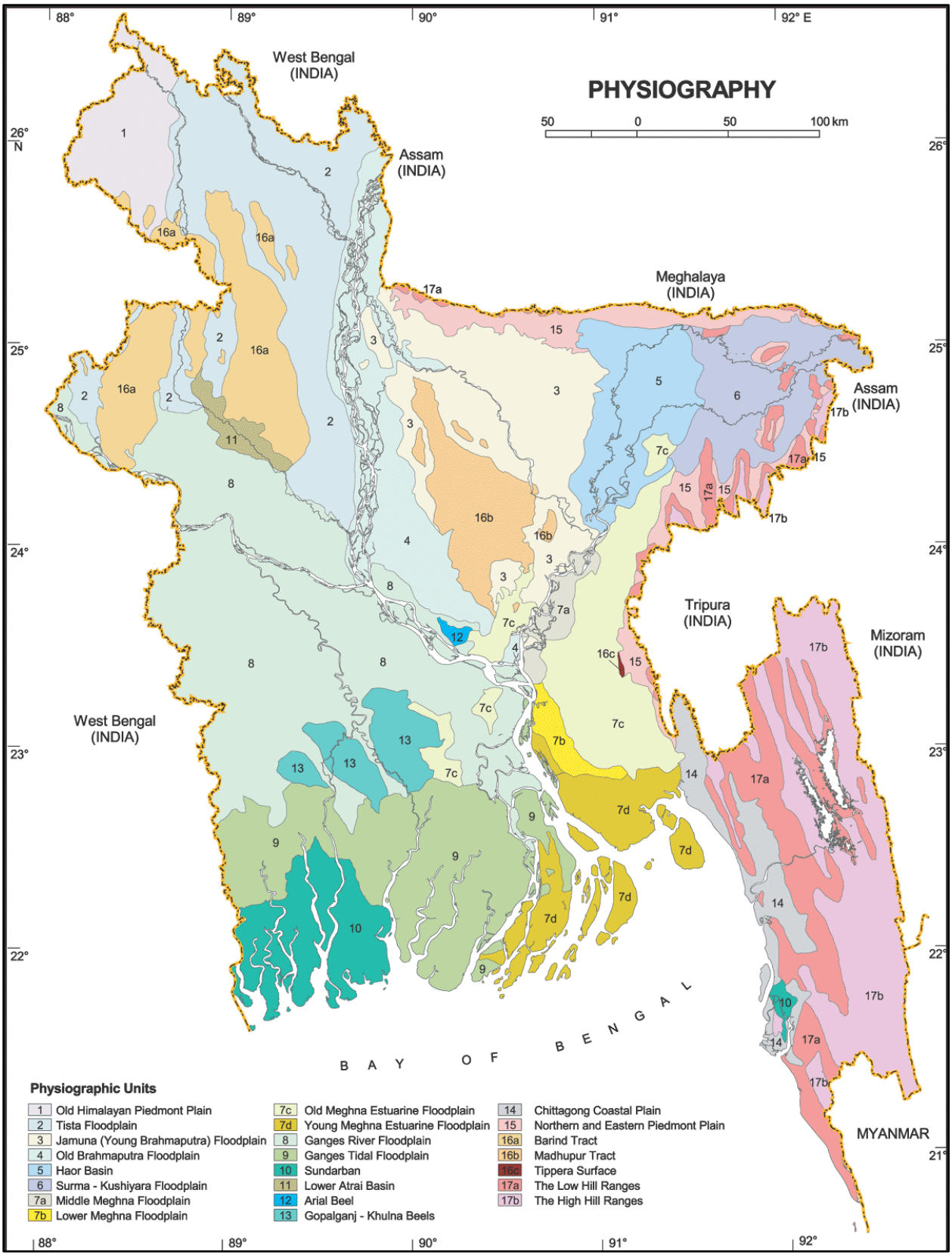


Figure 3.1: Physiographic map of Bangladesh (Source: SRDI, 1997)

3.1.3 Geological Setting

Bangladesh is divided into three major tectonic units: i) Stable Pre-Cambrian Platform in the northwest; ii) Geosynclinals basin in the southeast and (iii), a narrow northeast-southwest trending zone called the Hinge Zone separates the above two units almost through the middle of the country. This hinge zone is currently known as Paleo Continental Slope.

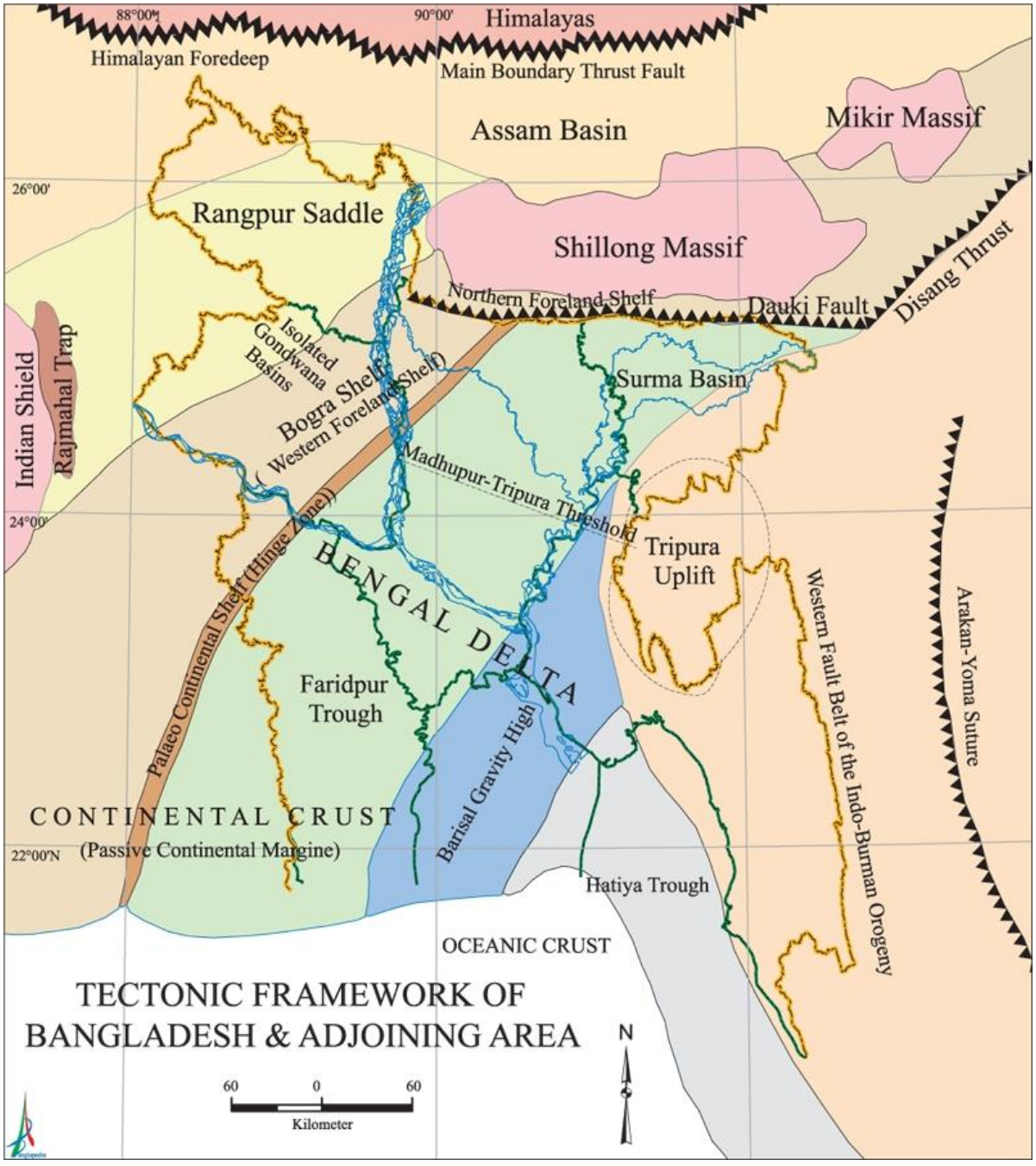


Figure 3.2: Tectonic map of Bangladesh (Source: Banglapedia, 2003)

i. **Stable Pre-Cambrian Platform:** It is the part of the basin that lies on the west and northwest of the line joining Calcutta and Mymensingh. In Bangladesh part of the Bengal Basin, the stable shelf can be divided into three major zones. They are: (i) Dinajpur Slope, (ii) Rangpur Saddle and (iii) Bogra Slope.

ii. **Hinge Zone (Calcutta-Mymensingh Gravity High):** Calcutta-Mymensingh Gravity High reflects a tectonic element known as Hinge Zone and more recently as palaeo continental slope in the framework of Bangladesh. The Hinge Zone is a narrow strip of about 25 km wide complex flexure zone, which separates the Bengal Foredeep from the shelf zone. It trends approximately N 30° E along the Calcutta-Pabna-Mymensingh gravity high and extends upto the western tip of Dauki fault. The Eocene limestone dips at about 20 in this zone as compared to 2-3 in the shelf zone. The seismic interpretation shows that the depth of the Sylhet Limestone - a strong seismic reflector - increases from 4000m to 9000m within a narrow zone of 25-km.

   In the northeast of Bangladesh, the Hinge Zone turns to the east and seems to be connected with the Dauki Fault, probably by a series of east-west trending faults.

iii. **Geosynclinal Basin:** The Geosynclinal Basin in the southeast is characterized by the huge thickness (maximum of about 20 km near the basin center) of clastic sedimentary rocks, mostly sandstone and shale of Tertiary age. It occupies the greater Dhaka-Faridpur-Noakhali-Sylhet-Comilla-Chittagong areas. The geosynclinal basin is subdivided into two parts i.e. **Bengal foredeep** to the west and **Fold belt** in the east.

3.1.4 Agro Ecological Zone of Bangladesh

The agro ecological zones of Bangladesh have been identified on the basis of four elements such as physiography, soils, land levels (in relation to flooding) and agro-climatology. Bangladesh has been tentatively divided into 30 agro ecological zones. These 30 zones have been subdivided into 88 agro ecological sub-regions, which have been further subdivided into 535 agro ecological units *(Banglapedia, 2003).*

The agro ecological resources are increasingly playing an important role in agricultural planning, technology transfer and specific bio-physical resource utilization programmer activities. A brief description of all 30 AEZ regions are being presented at a glance in the Table 3.1.

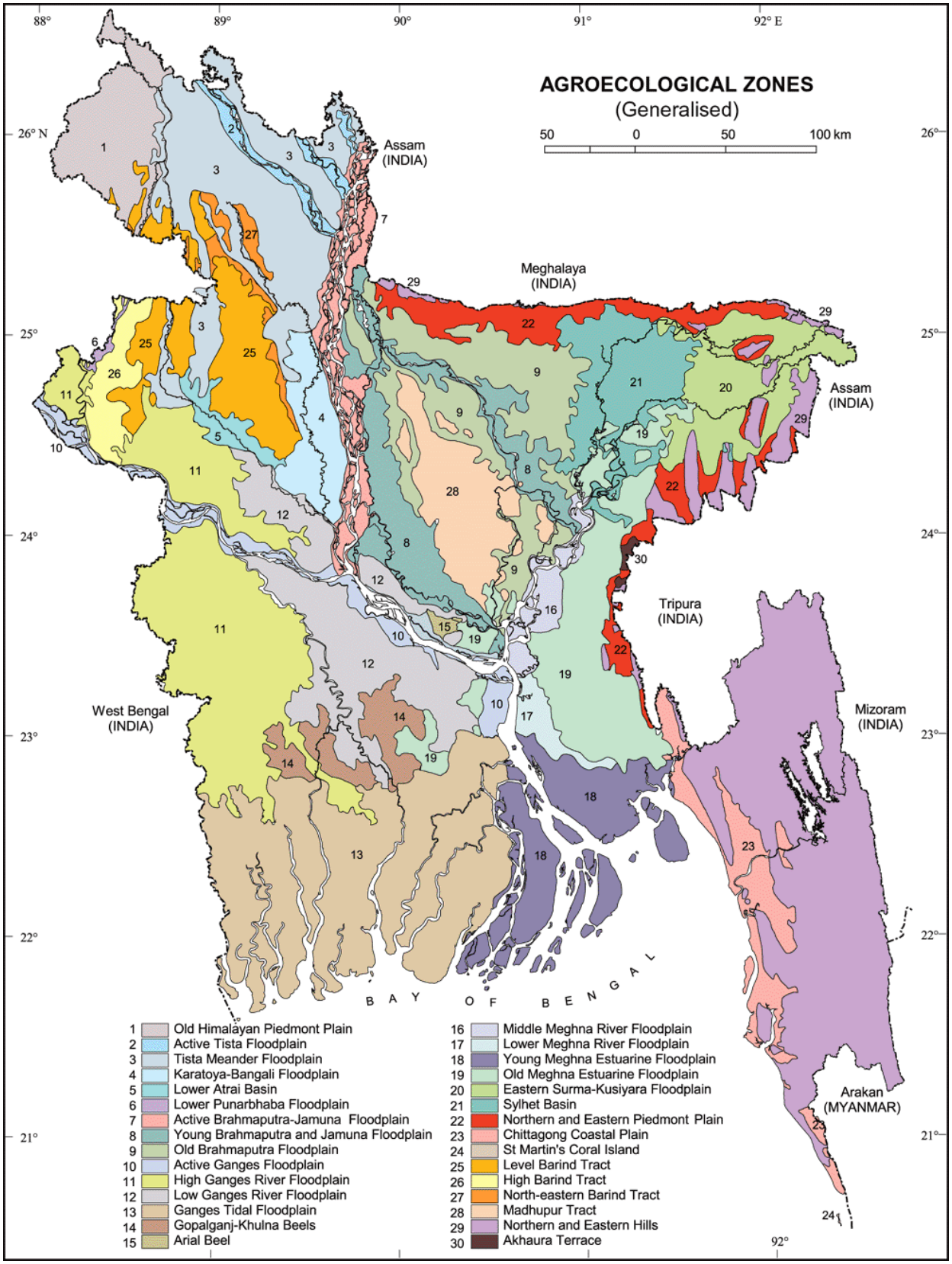


Figure 3.3: Agro ecolgical zones of Bangladesh (Source: Banglapedia, 2003)

Table 3.1: Agro Ecological Zones of Bangladesh

ID	Zones/Regions	Sub Regions	Sq. Km.
1.	Old Himalayan Piedmont Plain	a) North-central; b) Northern; c) Southern	4008
2.	Active Teesta Floodplain	Active Teesta Floodplain	830
3.	Teesta Meander Floodplain	a) Central; b) Eastern; c) Lower Atrai Floodplain; d) Lower Little Jamuna Floodplain; e) North-eastern and Southern North-western; f) Upper Little Jamuna and Middle Atrai Floodplain	9468
4.	Karatoya-Bangali Floodplain	a) Northern and Central; b) South-western	2577
5.	Lower Atrai Basin	Lower Atrai Basin	851
6.	Lower Punarbhaba Floodplain	Lower Punarbhaba Floodplain	129
7.	Active Brahmaputra-Jamuna Floodplain	Active Brahmaputra-Jamuna Floodplain	3190
8.	Young Brahmaputra and Jamuna Floodplain	a) High Jamuna Floodplain; b) Upper Brahmaputra Floodplain; c) Upper Brahmaputra-Jamuna Floodplain	5924
9.	Old Brahmaputra Floodplain	a) Bansi Valley; b) High; c) Low; d) Medium High; e) Medium Low	7230
10.	Active Ganges Floodplain	Active Ganges Floodplain	3334
11.	High Ganges River Floodplain	a) Central and Southern; b) Ganges-Mahananda Floodplain; c) Northern	13205
12.	Low Ganges River Floodplain	a) Central; b) Eastern	7968

ID	Zones/Regions	Sub Regions	Sq. Km.
13.	Ganges Tidal Floodplain	a) Khulna Sundarban; b) Nonsaline, calcareous; c)Nonsaline, calcareous and non-calcareous; d) Nonsaline, noncalcareous; e) Saline, Acid Sulphate Soils; f) Saline, calcareous and	17066
14.	Gopalganj-Khulna Beels	Beel centres	2247
15.	Arial Beel	Arial Beel	144
16.	Middle Meghna River	Middle Meghna River Floodplain	1555
17.	Lower Meghna River Floodplain	a) Calcareous, flood protected; b) Calcareous, unembanked; c) Noncalcareous, flood protected; d) Noncalcareous, unembanked	909
18.	Young Meghna Estuarine Floodplain	a) Nonsaline: Central Bhola; b) Nonsaline: Meghna Estuary Charland; c) Nonsaline: North Bhola; d) Saline: Central Bhola; e) Saline: Noakhali, Hatiya and Meghna Estuary; f) Saline: Sandwip and South Bhola	9269
19.	Old Meghna Estuarine Floodplain	a) Dhaka-Narayanganj-Demra Project Area; b) High: Old Meghna Estuarine Floodplain; c) Low: Daudkandi-Habiganj; d) Low: Dhaka- Shariatpur-Barisal; e) Low: Eastern Kishoreganj; f) Low: Gopalganj Beels margins; g) Low: Habiganj-North Brahmanbaria; h) Low: Titas Floodplain; i) Medium Low; j) Very poorly drained: Laksham-Begumganj	7740
20.	Eastern Surma-Kushiyara Floodplain	Eastern Surma-Kushiyara Floodplain	4622
21.	Sylhet Basin	Central and Southern; b) Northern; c) Western	4573
22.	Northern and Eastern Piedmont Plain	a) Northern and Eastern Basins; b) Northern and Eastern Plains and Basins; c) North-western Plains and Basins; d) South Sylhet Piedmont Plains	4038

ID	Zones/Regions	Sub Regions	Sq. Km.
23.	Chittagong Coastal Plain	a) Beach Ridges, Mangrove Swamp and Mud Clay; b) Mangrove Tidal Floodplain; c) Piedmont Plains and River Floodplains; d) Young Tidal Floodplain	3720
24.	St Martin's Coral Island	St. Martin's Coral Island	8
25.	Level Barind Tract	a) Highland and Medium Highland; b) Medium Lowland and Lowland	8
26.	High Barind Tract	High Barind Tract	16
27.	North-Eastern Barind Tract	a) Mainly poorly drained; b) Mainly well drained; c) Mixed well drained and poorly drained	1079
28.	Madhupur Tract	a) Mainly poorly drained level terrace; b) Mainly well drained dissected terrace	4244
29.	Northern and Eastern Hills	a) Low hills and Piedmont Plains; b) Mainly high hill ranges; c) Mainly low hills	18171
30.	Akhaura Terrace	Akhaura Terrace	113

(Source: FAO/UNDP, 1988)

3.1.5 Flora of Bangladesh

More than 6,000 plant species occur in Bangladesh, of which about 300 are exotic and 8 are endemic. Of the total number of plant species 3611 are angiosperms (flowering plants), and 7 are gymnosperms. Ninety-five vascular plants have been rated as threatened, of which 92 are angiosperms, and 3 gymnosperms. About 300 species and varieties of algae have been recorded from freshwater habitats alone. There are many more in brackish water and seawater habitats. The fungal flora are about 275. There are about 250 species of bryophytes in the country. Of the 250 species of pteridophytes, 230 are ferns. The main types of forests that occur in Bangladesh are the following: (i) Tropical evergreen and semi-evergreen; (ii) Tropical moist deciduous (inland soil forests); (iii) Tidal swamp forest; and (iv) Fresh water swamp forest. The tropical evergreen and semi-evergreen forests are more prevalent on the

lower slopes of the hills from the plain land up to 600 meters in the NE and SE of the country. Tropical moist deciduous forests are a mixture of several species in the top canopy.

Mangrove forest is limited to the Ganges delta in the south (Sundarbans) and the Chakaria Sundarban (now heavily degraded) in the delta of the Matamuhuri River, south of Chittagong in the SE. Freshwater swamp forests, completely inundated during the rainy season, are often called 'reedlands' (locally known as Pajuban) due to the predominance of reeds like Nal (*Phragmites karka*), Khagra (*Saccharum spontaneum*), and Ekra (*Eranthus ravannae*). Tree species include Hijal (*Barringtonia acutangula*), Jarul (*Lagerstroemia speciosa*), and Bhurii/Pitali (*Trewia nudiflora*). These forests are found in the low-lying areas (haors) of Sunamganj and North Sylhet in the NE of the country. *(Banglapedia, 2003)*

List of Plants of Inland Wetlands, Sundarbans and Tanguar Haor have been given in the following Annexures:

- Annexure 6A: Plants of Inland Wetlands
- Annexure 6B: Plants of Sundarban Mangrove Forest
- Annexure 6C: Plants of Tanguar Haor

3.1.6 Fauna of Bangladesh

Bangladesh is home to roughly 53 species of amphibian, 19 species of marine reptiles, 139 species of reptile, 380 species of birds, 116 species of mammals and 5 species of marine mammals *(Khan et al., 2008)*. In addition to the large bird count, a further 310 species of migratory birds swell bird numbers each year. It has the Bengal tiger, Asian elephant, hoolock gibbon, Asian black bear and other flagship species. The vast majority of these creatures currently dwell in an area of land that is some 150,000 sq kilometers in size. However, this does not mean all is well with the country's natural heritage. So far a number of creatures have disappeared completely from the country and a further 201 species are threatened. The dhole, also called the Asiatic wild dog, is now an endangered species. Notable animal species that have disappeared from Bangladesh are the greater one-horned rhinoceros, the Asian two-horned rhinoceros, the gaur, the banteng, swamp deer, nilgai, Indian wolf, wild water buffalo, marsh crocodile and common peafowl. The majority of the human population lives in or around large cities and this has helped to limit deforestation to some extent. However, the growth rate continues to increase and this has placed large demands on the environment and lead to subsequent clearing of numerous natural habitats.

Though several areas are protected under law, a large portion of Bangladeshi wildlife is threatened by this growth.

In Bangladesh, 253 species of freshwater fish and 401 species of marine fishes have been identified. List of birds and animals of Tanguar Haor have been given in Annexures 6D and 6E. Annexure 6F shows the list of freshwater fisheries of the country.

3.2 Environmental Setting

3.2.1 Hydrology of Bangladesh

Hydrological Regions: For studying and taking up projects of water sector, the National Water Management Plan, 2004 approved by the Government, divided the country into 8 hydrological regions. The regions are:

1. North West (NW)
2. North Central (NC)
3. North East (NE)
4. South West (SW)
5. South Central (SC)
6. South East (SE)
7. Eastern Hill (EH)
8. River & Estuary (RE)

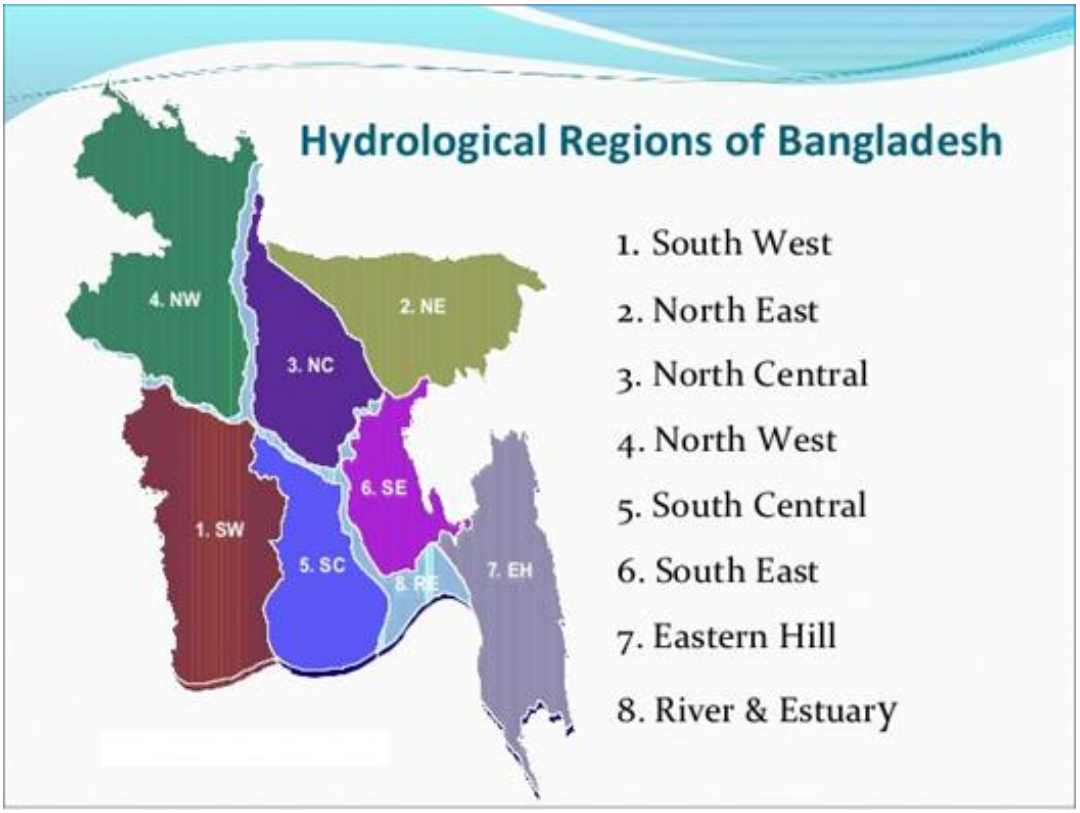


Figure 3.4: Hydrological regions of Bangladesh (Source: NWMP, 2004)

Floods of Bangladesh: Bangladesh is prone to flooding. In a normal year, about 20% of the land mass is inundated due to flooding of river water. Coastal flooding, combined with the bursting of river banks is common, and severely affects the landscape and society of Bangladesh. 80% of Bangladesh is floodplain, and it has an extensive sea coastline, rendering the nation very much at risk of periodic widespread damage. Small scale flooding in Bangladesh is somehow beneficial to the agricultural sector, as sediment deposited by floodwaters fertilizes fields. The water is required to grow rice, so natural flooding replaces the requirement of artificial irrigation, which is time consuming and costly to build. Salt and residual pesticides deposited on fields from high rates of evaporation is removed during floods, preventing the land from becoming infertile.

The Table 3.2 shows the severe floods, which caused inundation of more than 25% of total land area of Bangladesh.

Table 3.2: Severe Flood Affected Areas in Bangladesh (25% and above inundation)

Year	Flood Affected area		Year	Flood affected area	
	Sq. Km	%		Sq. Km	%
1954	36,800	25	1971	36,300	25
1955	50,500	34	1974	52.600	36
1962	37,200	25	1987	57,300	39
1963	43,100	29	1988	89,970	61
1968	37,200	25	1998	1,00,250	68
1969	41,400	28	2004	55,000	38
1970	42,400	29	2007	62,300	42.21

[Source: Statistical Yearbook, 2009]

Riverbank Erosion: Riverbank Erosion is an endemic and recurrent natural hazard in Bangladesh. When rivers enter the mature stage (as in the case with the three mighty rivers, Ganges, Brahmaputra and Meghna) they become sluggish and meander or braid. These oscillations cause massive riverbank erosion. Every year, millions of people are affected by

erosion that destroys standing crops, farmland and homestead land. It is estimated that about 5% of the total floodplain of Bangladesh is directly affected by erosion. At present, bank erosion and flood hazards in nearly 100 upazilas have become almost a regular feature. Of these, 35 are severely affected. *(Banglapedia, 2003)*

3.2.1.1 River System

The rivers of Bangladesh are considered as the lifeline of the people. These rivers generally flow towards south. The larger rivers serve as the main source of water for cultivation and as the principal arteries of commercial transportation. Rivers also provide fish, an important source of protein. Flooding of the rivers during the monsoon season and river bank erosion cause enormous hardship and hinders development, but fresh deposits of rich silt replenish the fertile but overworked soil. The rivers also drain excess monsoon rainfall into the Bay of Bengal. Thus, the great river system is at the same time the country's principal resource and source of its greatest hazard.

As also mentioned earlier, Bangladesh is situated at the confluence of three mighty rivers the Ganges, the Brahmaputra and the Meghna. Apart from these three rivers, there are many rivers which create a net-like network covering the whole country. Bangladesh has unique hydrological The country has 405 rivers *(BWDB, 2011)* of which 57 are trans-boundary rivers. Annexure 1 shows the list as well as important information of the rivers of the country. A map of its river network is also given in the Figure 3.5. Three large rivers systems (Brahmaputra-Jamuna, Ganges-Padma and Surma-Meghna) of the world covering a combined total catchments area of about 1.7 million sq. km. extending over Bhutan, China, India and Nepal, flow through this country. Out of these huge catchments only 7% lies within Bangladesh. The fourth river system lies in the Chittagong region of the country.

Rivers may be classified into three broad categories depending on the flow range and are as follows:

i) **Major Rivers:** 300 to 120,000 cumec e.g. Ganges, Brahmaputra, Padma, Meghna
ii) **Semi major Rivers:** 100 to 15000 cumec e.g. Old Brahmaputra, Dhaleswari, Gorai, Arial Khan, Surma, Kushiyara, Teesta etc.
iii) **Minor River:** 1 to 1000 cumec e.g. Sitalakhya, Buriganganga, Khowai, Manu, Gumti, Dharla, Dudkumar, Karnafuli, Halda, Sangu etc.

According to runoff characteristics, streams or rivers may be classified into 3 categories which are:

i) **Perennial:** The rivers which always carries some flow. During dry months water table remains above the stream bed.
ii) **Intermittent:** During the dry months, there is no flow in the river and there is limited contribution from ground water.
iii) **Empherical:** These rivers do not have any base flow contribution. The flashy hilly streams are of this type.

In Bangladesh rivers have also been classified as **(i) Main river, (ii) Distributaries, (iii) Tributaries and (iv) Branches**.

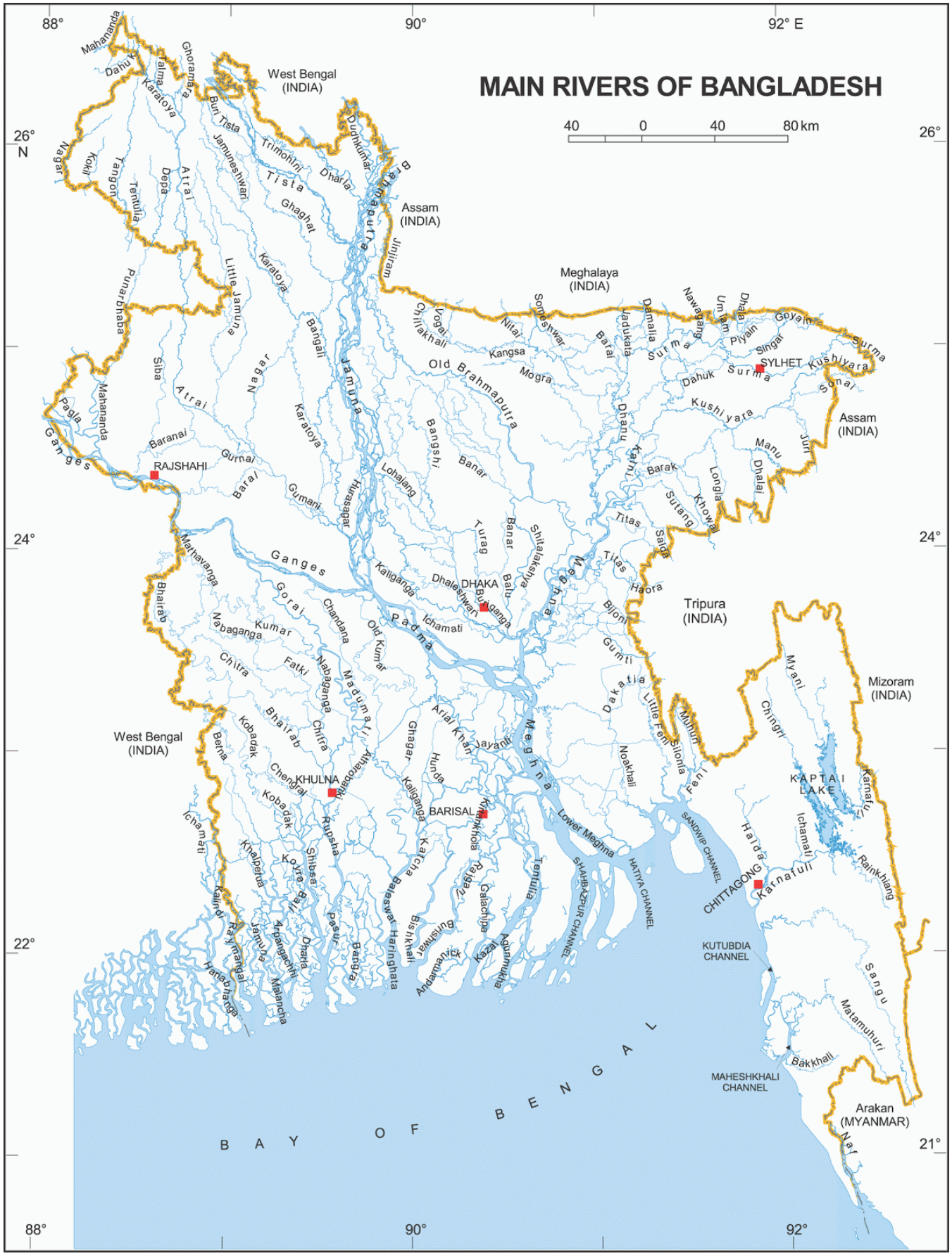


Figure 3.5: River system of Bangladesh (Source: BWDB, 2011)

When a river starts flowing through different channels (as in the case of braided channel), each of the new course is called the branch channel of the main river. For example, the river Barak bifurcates into two branch streams namely Surma and Kushiyara. When a smaller river takes off from the main river, the smaller one is termed as distributary. For example, the Old Brahmaputra is a distributary of the Brahmaputra/Jamuna. When a comparatively smaller river falls into a main river, it is termed as tributary of the main river. For example, the Teesta is a tributary of the Brahmaputra/Jamuna.

The river systems of the country can be divided into four major systems, which are:

1. Brahmaputra-Jamuna River System
2. Ganges-Padma River System
3. Surma-Meghna River System
4. Chittagong Region River System

Brahmaputra-Jamuna River System: Brahmaputra-Jamuna and old Brahmaputra, with their main tributary Teesta, and a good number of small tributaries and distributaries constitute the largest floodplain of Bangladesh.

The Brahmaputra enters Bangladesh from east of Bhabanipur (India) and northeast of Kurigram district. It first flows south and then turns southeast and travels through the Madhupur Tract to meet the Meghna near Bhairab Bazar. Among the major rivers, Brahmaputra-Jamuna is the most energetic and has the highest stream power. The tributaries, distributaries and branches of the Brahmaputra-Jamuna River System is given in Table A-1 of Appendix A. The map of Brahmaputra-Jamuna River System is shown in Figure A-1 in Appendix A.

Ganges-Padma River System: Ganges River is one of the largest river systems of the world and an important river flowing through India and Bangladesh. The Ganges rises near the Tibet-Indian border. The Bhagirathi is accepted traditionally as the original Ganges. The source is Gangotri glacier located at an altitude of about 3,900m in the Himalayas. The Bhagirathi joins its western tributary the Jahnavi, a little away to the north of the main Himalayan range and about 11 km below the Gangotri temple. The combined river then cuts through the main Himalayan range through a magnificent gorge in which the river bed is 3,960m below the peaks on either side. The river flows in a southeasterly direction across India and crosses the western border of Bangladesh in Nawabganj district. Inside the country,

flowing almost in the same direction it meets the Jamuna (the Brahmaputra) at Goalondaghat and then further down meets the Meghna at Chandpur. From the confluence with the Jamuna to the confluence with the Meghna the river is named Padma. The Ganges has a total length of about 2,600 km up to its confluence with the Jamuna and a catchment area of about 10,87,400 sq. km of which about 46,300 sq. km lies within Bangladesh.

The Bhagirathi-Hugli, Gorai-Madhumati and Arial Khan are three second-order rivers of the system. The Jalangi, Bhairab, Mathabhanga, Kobadak, Bhadra, Ichamati, Kumar, Nabaganga are some other important streams of the delta. Among the tidal or coastal creeks, the Matla, Hariabhanga, Saptamukhi, Malancha, Pasur, Haringhata, Rabanabad channel, Tentulia and Hatiya channels are worth mentioning. The Sundarbans, which occupies the southwestern deltaic coast, is also famous for its complex network of tidal creeks.

The main channel of the Ganges-Padma has long been maintaining a southeasterly direction. At the same time, numerous deltaic spill-channels, particularly those of the Sundarbans, clearly exhibit some abnormal and haphazard tendency of flow-direction, which has given rise to the existing complex maze of the drainage system in the region. Most of the deltaic rivers and all of the Sundarbans channels experience a marked tidal influence. The tributaries, distributaries and branches of the Ganges-Padma River System is given in Table A-2 of Appendix A. The map of Ganges-Padma River System is shown in Figure A-2 in Appendix A.

Surma-Meghna River System: Surma-Meghna River System is the longest river (669 km) system in the country. It also drains one of the world's heaviest rainfall areas (e.g. about 1,000 cm at Cherapunji, Meghalaya, India). East of Brahmaputra-Jamuna river system is Surma-Meghna River System. The Surma originates in the hills of Shillong and Meghalaya of India. The main source is Barak River, which has a considerable catchment in the ridge and valley terrain of Naga-Manipur hills bordering Myanmar. Barak-Meghna has a length of 950 km of which 340 km lies within Bangladesh. On reaching the border with Bangladesh at Amalshid in Sylhet district, Barak bifurcates to form the steep and highly flashy rivers Surma and Kushiyara.

Between the Surma and the Kushiyara, there lays a complex basin area comprised of depressions (Haors). Most of the Surma system falls in the Haor basin, where the line of drainage is not clear or well defined.

Meghna has two distinct parts. Upper Meghna from Bhairab Bazar to Shaitnol is comparatively a small river. Lower Meghna below Shaitnol is one of the largest rivers in the world, because it is the mouth of Ganges-Padma and Brahmaputra-Jamuna rivers. It is a tidal reach carrying almost the entire fluvial discharge of Ganges, Brahmaputra and Upper Meghna River.

The tributaries, distributaries and branches of the Surma-Meghna River System is given in Table A-3 of Appendix A. The map of Surma-Meghna River System is shown in Figure A-3 in Appendix A.

Chittagong Region River System: Chittagong Region River System the Chittagong region consists of the 5 hilly districts of Chittagong division namely Chittagong, Cox's Bazar, Bandarban, Rangamati and Khagrachhari. It is bounded by the Bay of Bengal on the south and west, the Naf river with Myanmar on the southeast, and India on the east. The region is characterized by three distinct ecological zones: inter-tidal zone, coastal plains and extensive hill areas. The remainder of the region consists of plains. The total area is approximately 19,956 sq. km with a hilly area of 1,300 sq. km.

The major rivers of this region are: Karnafuli and its tributaries (e.g. Rainkhiang, Kasalong, Halda, Ichamati etc.); Bakkhali, Sangu, Matamuhuri, Naf, and Feni. The Kutubdia and Maheshkhali channels are the coastal channels of the region. The Karnafuli is the principal river of the region. It originates in the Lushai Hills of Mizoram (India), flows through Rangamati and the port city of Chittagong and discharges into the Bay of Bengal near Patenga. The river is flashy and its length is about 131 km. Rainkhiang, Sublong, Thega, Kasalong, Ichamati and Halda are its main tributaries. Its major distributaries are Saylok and Boalkhali. The tributaries, distributaries and branches of the Chittagong Region River System is given in Table A-4 of Appendix A. The map of Chittagong Region River System is shown in Figure A-4 in Appendix A.

3.2.1.2 Groundwater

Groundwater is the main source of water for drinking and irrigation in Bangladesh. The sediments underlying most of Bangladesh provide good aquifers which are widely exploited to supply domestic and irrigation water, except in the hilly areas. In most of the areas except major city areas like Dhaka and Barind Tract, aquifers are mostly recharged every year by rainfall, seasonal flooding and percolation of water through river beds. Due to abstraction of

groundwater, serious depletion of groundwater table around major cities, particularly in Dhaka has reached at an alarming situation. Similar situation is reported for the Barind areas (due to excessive withdrawal of groundwater for irrigation purposes. Currently, 35,322 deep tube wells, 1,523,322 shallow tube wells and 170,570 low lift pumps are working in Bangladesh to provide water for irrigation. About 79% of the total cultivated area in Bangladesh is irrigated by groundwater, whereas the remaining is irrigated by surface water. The Arsenic contamination in groundwater is increasing at an alarming rate. Today, in Bangladesh, an estimated 35–77 million people have been chronically exposed to Arsenic via drinking water. An estimated 25% of the wells exceed Arsenic levels according to the Bangladesh standard. *(CSISA-MI, 2015)*

In the last two decades, increased groundwater accessibility resulting from the expansion of deep and shallow tube wells helped Bangladesh attain near self-sufficiency in rice. This has resulted in serious problems, most notably excessive drawdown in intensively irrigated areas, and the deterioration of groundwater quality. As such, Government has decided not to expand further deep tube wells in irrigation areas. Increasing energy prices are also threatening the sustainability of Bangladesh's groundwater irrigated economy.

Artesian flow (where groundwater comes to surface naturally) occurs in a few places on piedmont plains near the foot of the Northern and Eastern Hills and in some Madhupur Tract valleys *(Brammer, 2012).*

3.2.2 Climate

Bangladesh is located in the tropical monsoon region and its climate is characterized by high temperature, heavy rainfall, often excessive humidity, and fairly marked seasonal variations. The most striking feature of its climate is the reversal of the wind circulation between summer and winter, which is an integral part of the circulation system of the South Asian subcontinent. Bangladesh's climate has three major characteristics. They are, it is markedly seasonal, variable from year to year and it also varies over long period of time. An understanding of the characteristics of present climate is also important for assessing on-going and potential future changes in Bangladesh's climate.

Four main seasons are recognized. Within Bangladesh, the four seasons have the following characteristics:

The pre-monsoon season (Summer, March-May):

- March-May, has the highest temperature and evaporation rates.
- Occasional line-squalls give heavy rain showers with strong wind.
- The dates of onset of the season vary considerably from year to year, and so do the amounts of rainfall received.
- Tropical cyclones affect coastal areas in some years.
- Average temperatures in April vary from about 27°C in the northeast to 30°C in the extreme west central part of the country. In some places in Rajshahi and Kushtia districts the maximum temperature in summer season rises up to 40°C or more.
- March and April are the least humid months over most of the western part of the country. The lowest average relative humidity (57%) has been recorded in Dinajpur in the month of March.

The Monsoon Season (Rainy, June-September):

- June-September, has the highest rainfall, humidity and cloud cover.
- More than 80% of annual rainfall usually occurs in this season. Totals vary greatly from year to year. The start and end dates of the period in terms of rainfall exceeding evapotranspiration rates can vary by a month or more between years.
- Temperature decreases slightly during the the rainy season. Widespread cloud covers cause dampening of temperature during the latter part of the pre-monsoon season.
- Average temperatures in July vary from about 27°C in the southeast to 29°C in the northwestern part of the country.
- The relative humidity is over 80% during June through September.
- The mean pressure is 1,005 millibars during March through September.

The Post-Monsoon Season (Autumn, October-November):

- October-November, is hot and humid with occasional rainfall and increasing amounts of sunshine.

- The beginning and end dates of the season vary greatly between years, and so do the amounts of rainfall received. Tropical cyclones are again liable to affect coastal areas.

The Dry Season (Winter, December-February):

- December-February, is relatively cool and sunny, with little and unreliable rainfall.
- January is the coldest month in Bangladesh. Average temperatures in January vary from about 17°C in the northwestern and northeastern parts to 20°-21°C in the coastal areas. In late December and early January, minimum temperature in the extreme northwestern and northeastern parts of the country reaches within 4°C to 7°C.
- The least humid months in the country are January to March.
- The mean atmospheric pressure is 1,020 millibars in January

Cyclones and Cyclonic Surges: Bangladesh, due to its unique geographic location and funnel shaped coast of the Bay of Bengal, suffers from devastating tropical cyclones frequently. The funnel-shaped northern portion of the Bay of Bengal causes tidal bores when cyclones make landfall due to which thousands of people living in the coastal areas are affected. Some of the most devastating natural disasters recorded in history with high casualties were tropical cyclones that hit the region. Among them, the 1970 Bhola cyclone alone claimed more than 500,000 lives. The Great Cyclone of 1991, crossed the Bangladesh coast during the night. The loss of property was estimated at about Tk 60 billion. The death toll was estimated at 150,000; cattle head killed 70,000. In 2007(15-17 November), severe cyclonic storm 'Sidr' causes immense damage in southern part of Bangladesh; about 3000 persons killed. Severe Cyclonic Storm Aila was the worst natural disaster to affect Bangladesh since Cyclone Sidr. Aila formed over the Bay of Bengal on May 27, 2009. The storm was responsible for at least 339 deaths across Bangladesh and India; more than 1 million people were left homeless. Severe cyclones occur mostly during pre-monsoon (April-May) and post-monsoon (September-November) periods and they are the ones which cause the most destruction. Figure 3.6 shows the tracks of some major cyclones that hit Bangladesh. A list of major cyclones is given in Table 3.3.

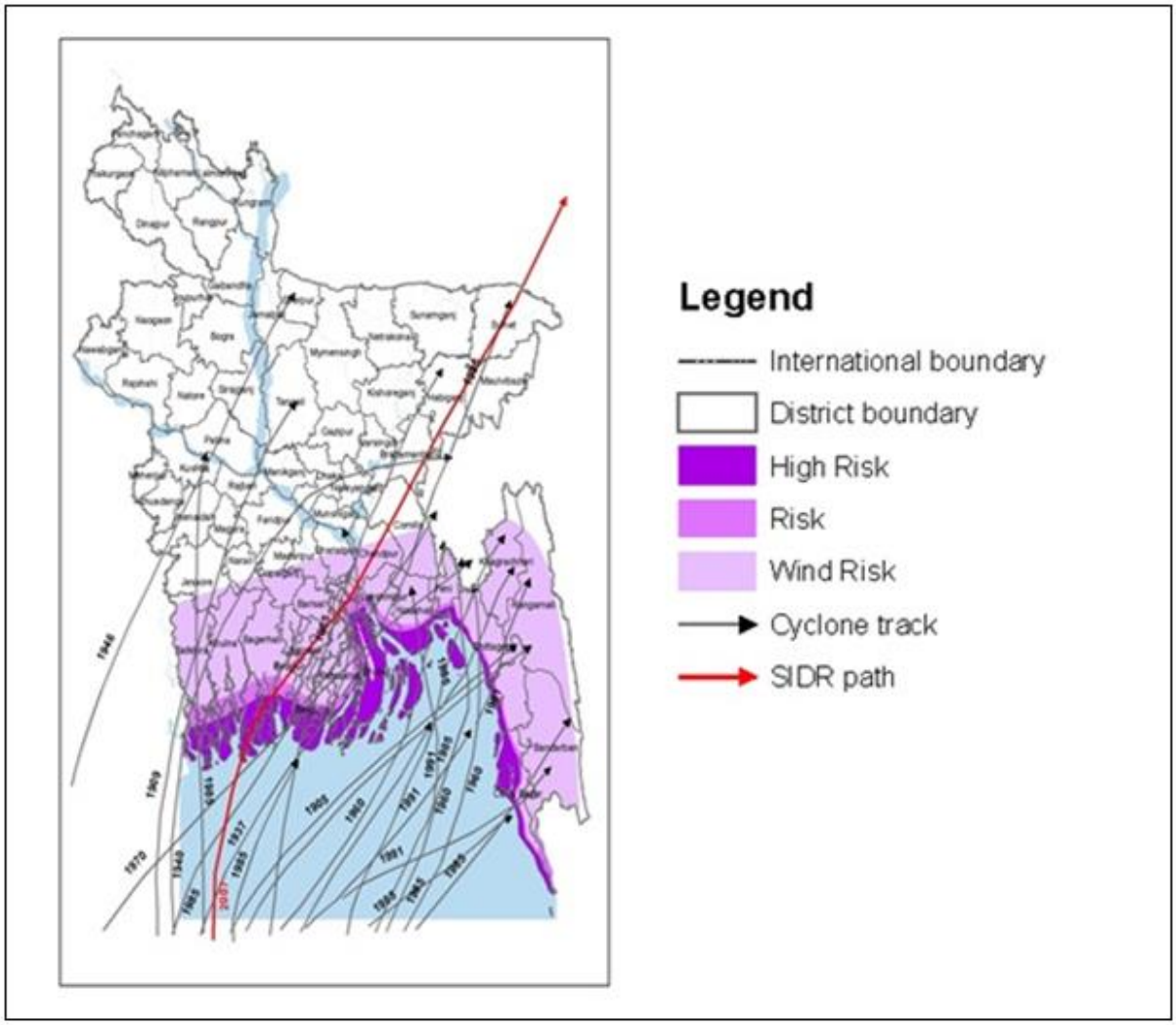


Figure 3.6: Some major cyclone tracks

Table 3.3: Some Major Cyclones of Bangladesh

Sl	Date of Occurrence	Landfall Area	Wind Speed (kph)	Tidal Surge (ft)	Loss/Damage
1.	1584	Bakerganj (presently Barisal) and Patuakhali	-	-	People & livestock killed= 2000000
2.	May, 1822	Barisal, Hatiya Island and Noakhali district	-	-	People killed= 40000 Livestock killed= 100000
3.	31.10.1876	Meghna estuary and coasts of Chittagong, Barisal, Noakhali	-	12	People killed= 200000
4.	24.10.1897	Chittagong	-	-	People killed= 18000

Sl	Date of Occurrence	Landfall Area	Wind Speed (kph)	Tidal Surge (ft)	Loss/Damage
5.	November, 1904	Sonadia	-	-	People killed= 143
6.	16.10.1909	Khulna	-	-	People killed= 698 Livestock killed= 70654
7.	October, 1913	Muktagachha upazila (Mymensingh)	-	-	People killed= 500
8.	24.09.1917	Khulna	-	-	People killed= 698 Livestock killed= 28029
9.	May, 1941	Eastern Meghna estuary	-	-	-
10.	17-19 May, 1948	Between Chittagong and Noakhali	-	-	People killed= 1200 Livestock killed= 20000
11.	11.10.1960	Chittagong	160	5	People Killed = 3000
12.	31.10.1960	Chittagong	193	6	People Killed = 5149
13.	09.05.1961	Chittagong	160	2.5-3	People Killed = 11468
14.	30.05.1961	Chittagong(Near Feni)	160	2-5	-
15.	28.05.1963	Chittagong- Cox's Bazar	209	8-12	People Killed = 11520
16.	11.05.1965	Chittagong- Barisal Coast	160	12	People Killed = 17279
17.	05.11.1965	Chittagong	160	2.5-4	People Killed = 873
18.	15.12.1965	Cox's Bazar	210	2.5-3	Fishermen missing = 1000
19.	01.11.1966	Chittagong	120	6-7	People Killed = 850
20.	23.10.1970	Khulna-Barisal	163	Moderate	No heavy damage report received
21.	12.11.70	Chittagong	224	3-10	People Killed= 200000 (officially) =500000(unofficially)
22.	28.11.74	Cox's Bazar	163	9-17	People Killed = 20 People wounded = 50 People missing = 280 Cattle killed =1000
23.	10.12.81	Khulna	120	3-6	People Killed = 72
24.	15.10.83	Chittagong	93	-	People Killed = 43 Fishermen missing = 100
25.	09.11.83	Cox's Bazar	136	1.5	Fishermen missing = 300
26.	24.05.85	Chittagng	154	4.5	People Killed = 4264 People missing = 6805 Livestock lost = 135033
27.	29.11.88	Khulna	160	0.5-4.5	People Killed = 6133 People missing = 6000
28.	18.12.90	Cox's Bazar Coast	115	1.5-2	-
29.	29.04.91	Chittagong	225	4-7	People Killed = 138882 People wounded = 1390540

Sl	Date of Occurrence	Landfall Area	Wind Speed (kph)	Tidal Surge (ft)	Loss/Damage
30.	02.05.94	Cox's Bazar- Teknaf Coast	278	1.5-2	People Killed = 188
31.	25.11.95	Cox's Bazar	140	3	-
32.	19.05.97	Sitakundu	232	4.5	People Killed = 155 Livestock killed = 3118
33.	27.09.97	Sitakundu	150	3-1.5	People Killed = 78 People missing = 222
34.	20.05.98	Chittagong Coast near Sita Kundu	173	1	People Killed = 14 People wounded = 100
35.	17.10.99	Orissa Coast	-	-	-
36.	25.10.99	Orissa Coast	-	-	-
37.	28.10.00	Sundarban coast near Mongla	50-60	0.5-1.5	People killed =3 Fishermen reported missing = About 250
38.	16-10. 01	Andhra coast	65-85	-	-
39.	12.11. 02	Sundarban coast near Raimangal river	65-85	1.5-2	People killed =2 Fishermen reported missing = About180
40.	20.5. 03	Myanmar coast	65-85	3-5	-
41.	16.12.03	Andhra coast	98-115	-	-
42.	19.5.04	Cox's Bazar – AkyabCoast	65-90	1-1.5	26 small boats with fishermen were reported missing
43.	15.11.07 (Sidr)	Khulna- Barisal Coast Near Baleshwar River	223	4.5	People Killed = 3363 Livestock killed = 1778507
44.	25.5.2009 (Aila)	West Bengal- Khulna Coast near Sagar Island	70-90	1.5-2	People killed = 150

(Source: Banglapedia, 2003; T.S.Murty et al., 1986; Khalil, M.G., 1992; and Murty, T.S. and El-Sabh, M.I., 1992)

3.2.3 Climate Change

Bangladesh is the nation most vulnerable to global climate change in the world, according to German Watch's Global Climate Risk Index (CRI) of 2011. This is based on the analysis of impacts of major climate events that occurred around the world in the twenty-year period since 1990. Climate Change in Bangladesh is an extremely crucial issue and Bangladesh ranks first as the nation most vulnerable to the impacts of Climate Change in the coming decades *(Braun, 2010)*.

It is agreed by most climatologists that global temperature is rising and will continue to rise due to Greenhouse Effect (warming). The available climate models show wide variation of results for the Indian region (where Bangladesh is Situated).

The probable effects of global climate change have been examined in general by the Intergovernmental Panel for Climate Change (IPCC) and are regularly reviewed. The findings for Bangladesh have been studied in detail by Warrick, BCAS, Stratus and Huq amongst others. The most recent projections set out the changes anticipated in Bangladesh which are:

i) A rise in sea level in the order of 300mm by the year 2030 and 700 mm by 2075. This suggests a rise of 250 mm by 2025, at the rate of 10 mm/year.
ii) A rise in monsoon season temperature of 0.7°C by 2030 and 1.1°C by 2050. Dry season temperatures would rise by 1.3°C by 2030 and 1.8°C by 2050.
iii) An increase in monsoon rainfall of about 10% by the year 2030 and 25% by 2050. Dry season rainfall is projected to reduce in the long term.

In general, the high emission scenario is the worst case which is shown in the IPCC projection of climate change in South Asia sub region (A_1F_1 scenario, where A_1F_1 = highest future emissions scenario) *(IPCC, 2007).* The projections are:

- Increase in mean temperatures in the dry season (Dec-Feb). (+)1.17^{o}C in 2030 and increasing to (+)5.44^{o}C in 2100.
- Increase in mean temperature in the monsoon season (June-Aug), (+)0.54^{o}C in 2030 and increasing to (+)3.14^{o}C in 2100.
- Decrease in dry season rainfall (-) 3% in 2030 and (-) 16% in 2100.
- Increase in the monsoon season rainfall (+) 5% in 2030 and (+) 26% in 2100.
- The 'best estimates' of the sea level rise as predicted in the IPCC 2007 document range from (+) 0.28m in the case of low emission of greenhouse gases and (+) 0.43m in the high emission scenario by 2100. However, if melted water discharge of Greenland and Antarctica were to continue rising throughout the century, the sea level rise in the high emission scenario will be (+) 0.54m by 2100 i.e. in worst case the rise is 5.4mm/year.

The key consequences of climate change for Bangladesh as mentioned in the **NWMP, 2004** are quoted below:

“

- Worsening drainage congestion and waterlogging due to higher sea levels, raising of river bed levels and increased monsoon season rainfall. This will adversely affect agriculture in the monsoon season.
- Reduced dry season surface water availability and increased demand due to lower rainfall and higher temperatures and more abstraction upstream of Bangladesh. This will increase competition for water and threaten to increase salinization of coastal areas due to reduced dry season outflows.
- Disturbance of existing morphological processes by the changed balance between wet and dry season flows and changes in sediment transport and deposition caused by changes in flows and water levels. This will affect river bank erosion and channel sedimentation.
- Increased occurrence of extreme climate-induced events such as floods, droughts and cyclones. These will constrain social and economic development.”

The impact of climate changes in Bangladesh is shown in Table 3.4.

Table 3.4: Impact of Climate Change in Bangladesh

Sl	Immediate impact	Results
1	Sea level rise	• Coastal embankments overtopped • Saline intrusion into rivers and groundwater
2	Cyclones – increased frequency and severity	• Higher storm surges • Higher wind speed
3	Heavier more erratic rainfall in Ganges, Brahmaputra & Meghna basins in the monsoon season	• Higher river flows • Drainage congestion • Flooding in rural /urban areas
4	Lower more erratic rainfall at other times	• Droughts • Scarcity of drinking water

Sl	Immediate impact	Results
5	Melting of Himalayan glaciers	• Higher river flows in short to medium term • Then reduced flows and increased saline intrusion
6	Warmer and more humid weather	• Increased prevalence of disease and disease vector

(Source: Modified after MoEF, 2009)

3.2.4 Soils of Bangladesh

The country has been divided into seven soil tracts based on the geological origin of soils without considering the soil forming factors. Table 3.5 and Fig 3.7 show the soil tracts of the country.

Table 3.5: The Seven Soil Tracts of Bangladesh

Sl. No.	Soil Tracts	Area Sq. Km. (estimated)	Typical Soil Series*
1	Madhupur Tract	10,000	Tejgaon
2	Barind Tract	13,000	Amnura
3	Teesta Silt	16,000	Gangachara
4	Brahmaputra Alluvium	40,000	Ghatail
5	Gangetic Alluvium	27,000	Sara
6	Coastal Saline Tract	20,000	Barisal
7	Chittagong Hill Tract	15,000	Kaptai

[Source: Islam and Islam (1956), *SRDI (1965-1976)]

Rainfall is high in the north-east and gradually declines towards the west. Considering the climate as the most active pedogenic factor, Bangladesh is divided into three zones:

a. Humid
b. Semi-Humid and
c. Feebly Arid

A pedoclimatic zone was defined as representing an area where the climatic factor working on parent material has produced similar soils. Table 3.6 shows the pedoclimatic zones of the country.

Table 3.6: Pedoclimatic Zones of Bangladesh

Zone No.	Name of Pedoclimatic Zone	Areas and Associated Soil Type
Zone 1	Humid	The north-east and east submountainean hill tracts, south and south-east coastal lands. The probable soil association in the zone is a podzolic type including alluvial.
Zone 2	Semi-Humid	The north-northeast flat and the south-west lowland. The probable soil association being of degraded lateritic and alluvial.
Zone 3	Feebly Arid	The rest of Bangladesh. The probable soil association being of a lateritic and also of a pedocalic type including alluvial.

(Source: Karim & Hossain, 1957)

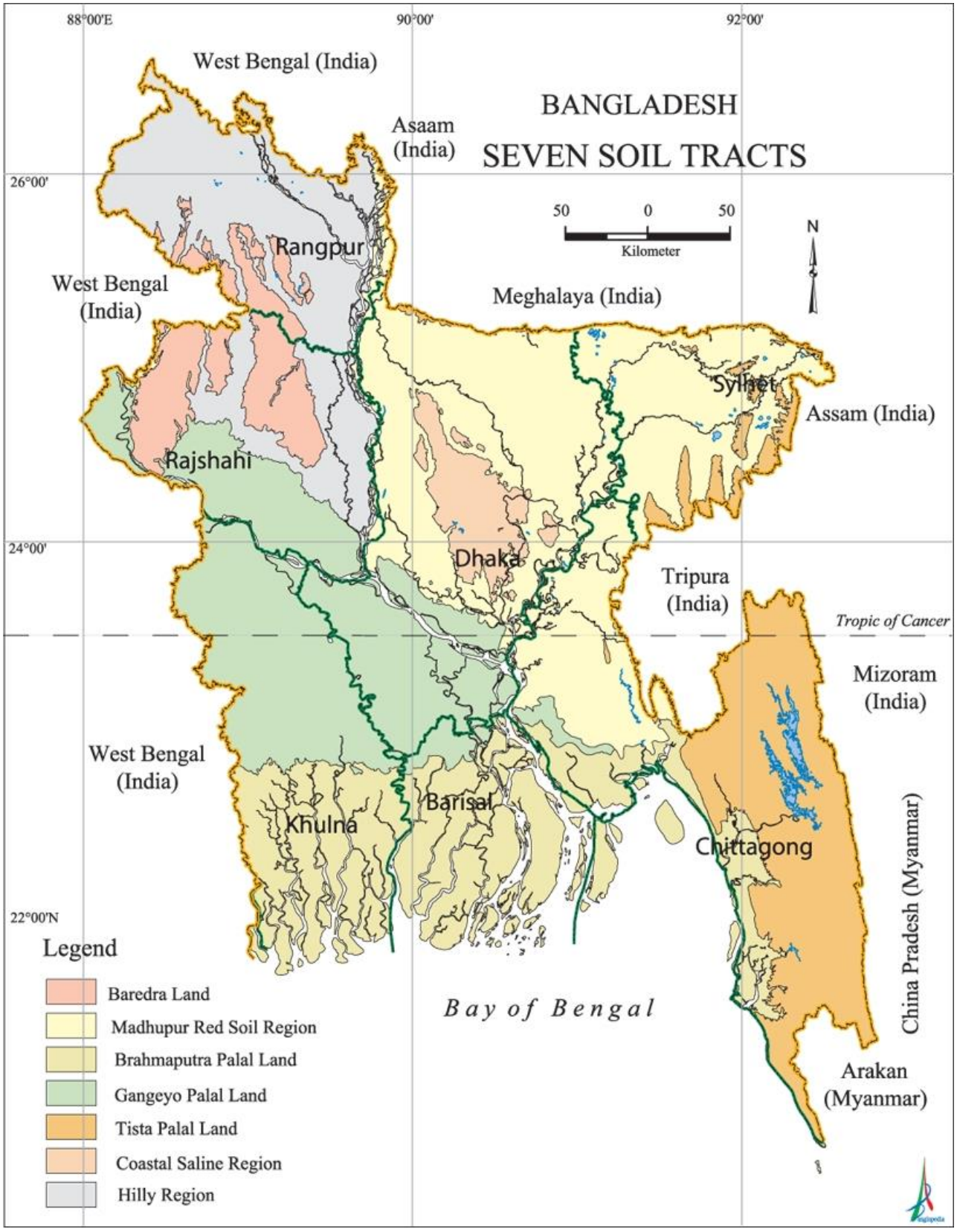


Figure 3.7: Seven soil tracts of Bangladesh (Source: Banglapedia, 2003)

The Ganges-Padma, Brahmaputra-Meghna and Surma-Meghna systems drain a basin of some 1.76 million sq. km and carries not only snowmelt water from the Himalayas but also runoff water from some of the highest rainfall areas of the world. Over millennia, the sediments carried by the huge discharges of these rivers have built a broad delta, forming most of the large area of Bangladesh and the submerged delta-plain in the Bay of Bengal. These huge sediments are the major sources of formation of 80% soils of the country. The remaining 20% of soils have been formed in Tertiary and Quaternary sediments of hills (12%) and in uplifted Pleistocene terrace (8%).

Soil classification: The Soil Resources Development Institute (SRDI) has identified about 500 soil series in Bangladesh. Soil series is a group of soils formed from the same kind of parent material under similar conditions of drainage, vegetation, climate and time, and having the same sequence of soil horizons with similar differentiating properties. Each soil series is known after a name of locality (e.g. Tejgaon series, Sara series, Ishwardi series, etc.). *(Banglapedia, 2003)*

All of these soil series have been mapped as Soil Association by the SRDI through reconnaissance soil survey carried out during 1965 and 1975. These soil series have been correlated with the FAO-UNESCO soil units of Fluvisols, Gleysols, Histosols, Planosols, Luvisols, Cambisols and Arenosols. According to the United States Department of Agriculture (USDA) soil taxonomy, these soil series are Entisols, Inceptisols, Histosols, Mollisols, Ultisols and Alfisols. *(Banglapedia, 2003)*

General Soil Type: These general soil types give a very broad level of generalization of soil characteristics. Each general soil type includes several kinds of soil series, developed in more than one kind of parent materials and may include a wide range of chemical and physical properties. Table 3.7 and Fig 3.8 shows the general soil types of the country.

Correlation of the General Soil types and FAO-UNESCO soil units of Bangladesh is given in Table 3.8.

Table 3.7: General Soil types of Bangladesh

Sl. No.	General soil type	Area (ha)	(%) of
1	Floodplain soils	9,718,722	78.96
2	Calcareous Alluvium	591,796	4.81
3	Non-calcareous Alluvium	562,242	4.57
4	Calcareous Brown Floodplain soils	478,518	3.89
5	Calcareous Grey Floodplain soils	170,767	1.39
6	Calcareous Dark Grey Floodplain soils	1,434,678	11.66
7	Non Calcareous Grey Floodplain soils	3,387,153	27.52
8	Non Calcareous Brown Floodplain soils	383,312	3.11
9	Non Calcareous Dark Grey Floodplain soils	1,599,645	13.00
10	Black Terai soils	83,408	0.68
11	Acid Basin clays	348,994	2.84
12	Acid Sulphate soils	226,647	1.84
13	Peat	130,005	1.06
14	Grey Piedmont Soils	215,279	1.75
15	Made-land	106,278	0.86
16	Hill soils (Brown Hill Soils)	1,561,472	12.69
17	Terrace soils	1,028,030	8.35
18	Shallow Red-Brown Terrace soils	72,549	0.59
19	Deep Red-Brown Terrace soils	189,380	1.54
20	Brown Mottled Terrace soils	34,235	0.28
21	Shallow Grey Terrace soils	265,427	2.16
22	Deep Grey Terrace soils	352,152	2.86
23	Grey Valley soils	114,287	0.93
Total soil area		**12,308,224**	**100.00**

(Source: FAO/UNDP, 1988)

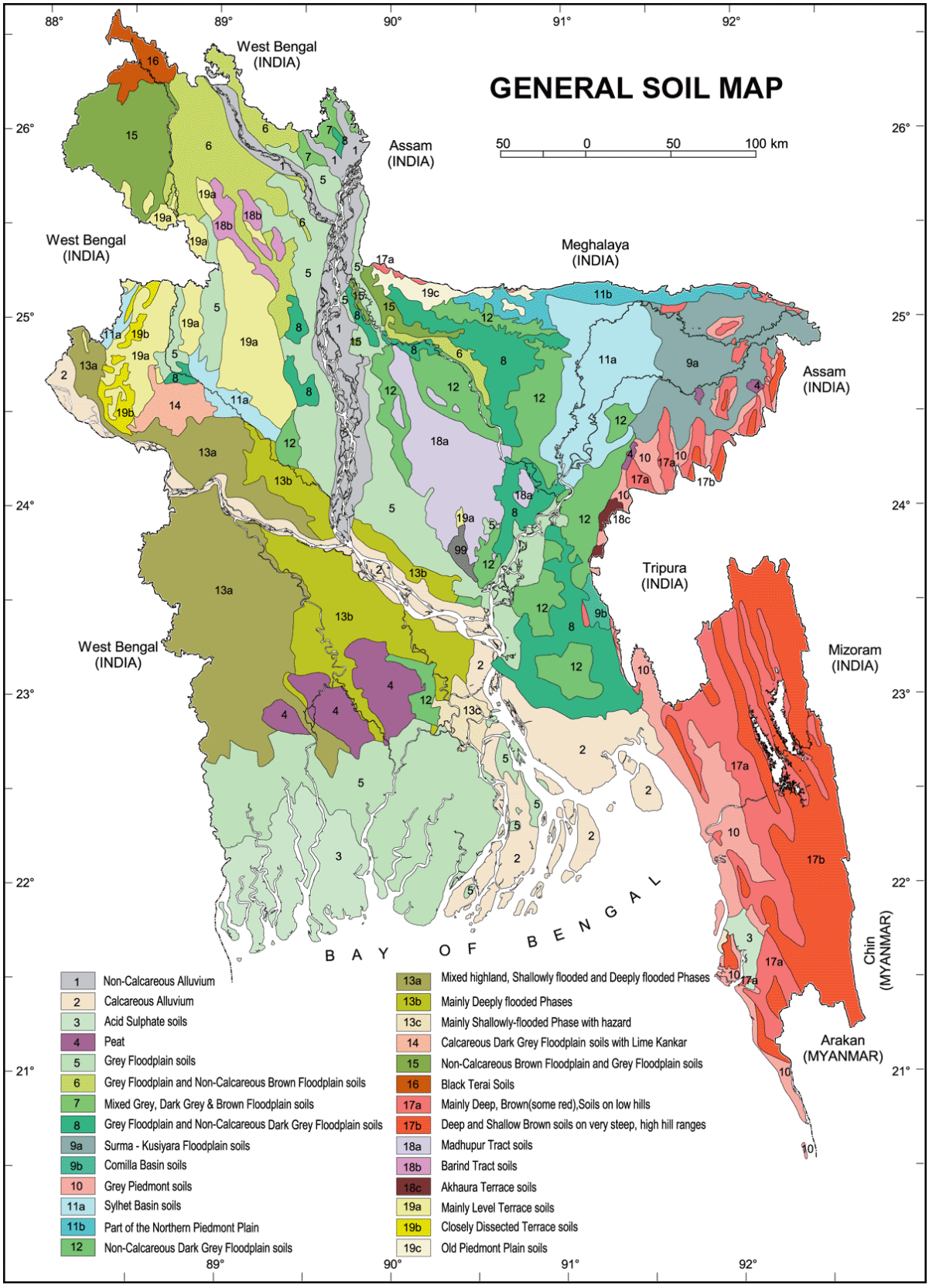


Figure 3.8: Generalized soil map of Bangladesh (Banglapedia, 2003)

Table 3.8: General Soil types and FAO-UNESCO soil units of Bangladesh

Sl.No.	Floodplain Sub-types of Soil	FAO-UNESCO soil units
1	Calcareous Alluvium Soils	They are mainly Calcaric Fluvisols
2	Non-calcareous Alluvium	Most of these soils have been included as Eutric Fluvisols
3	Calcareous Brown Floodplain soils	Most of these soils belong to Calcaric Gleysols
4	Calcareous Grey Floodplain soils	They are Calcaric Gleysols
5	Calcareous Dark Grey Floodplain soils	They are Calcaric Gleysols
6	Non-calcareous Grey Floodplain soils	Most of these soils have been included in Eutric Gleysols
7	Non-calcareous Dark Grey Floodplain soils	The majority of these soils are Eutric Gleysols
8	Non-calcareous Brown Floodplain soils	Most of these soils are Dystric/Eutric Gleysols or Cambisols
9	Black Terai soils	They are either Umbric or Mollic Gleysols
10	Acid Basin clays	These soils are Eutric, Dystric or Mollic Gleysols
11	Acid Sulphate soils	They are either Thionic Fluvisols or Thionic Gleysols
12	Peat	They have been included as Histosols
13	Grey Piedmont soils	They are mainly included in Dystric or Eutric Gleysols.
14	Made-land soils	These soils have been classified as Fimic Anthrosols
15	Hill soils (Brown Hill soils)	The majority of these soils are Dystric Cambisols and Haplic and Ferric Alisols
16	Terrace soils	The majority of them have been classified as Haplic and Gleyic Alisols
17	Deep Red Brown Terrace soils	They are mainly Ferric Alisols
18	Brown Mottled Terrace soils	They have been classified as Ferric Luvisols and Alisols
19	Shallow Grey Terrace soils	They have been classified as Eutric Planosols
20	Deep Grey Terrace soils	The majority of these soils are Albic Gleysols, Gleyic Luvisols and Gleyic Alisols
21	Grey Valley soils	They are Albic and Eutric Gleysols.

(Source: FAO/UNDP, 1988)

3.2.5 Land Use

Land use is the human activities that are directly related to land, making use of its resources or having an impact upon it. Land cover is the physical attributes of the land, while landuse is

a pattern of human activities undertaken within a socio-economic context. Natural land cover is changed by use of man in meeting cultivation, homestead or other demands.

Land use pattern in Bangladesh is determined by physiography, climate and land levels in relation to flooding. Of the three determinants, land levels in relation to flood depth are of major importance for land use. Even occupation types in the rural areas are dependent on flooding characteristics - depth, duration and timing. There are regional variations in the distribution of different land types and land use pattern. Land includes all land and water within the national boundaries of the country. Water bodies within land areas are therefore considered to be a part of land. The use of land is of paramount importance in a country which is thickly populated and still very reliant on primary production. Table 3.9 shows the land use of Bangladesh.

Table 3.9: Landuse, 2000 (in sq. km.)

No.	Classification	Dry Season (March)	Wet Season (September)
1.	**Rivers**	**6,400**	**7,700**
	Main rivers	2860	3940
	Rivers in Sundarbans	1660	1660
	Other rivers	1880	2100
2.	**Standing water bodies**	**4,245**	**9500**
	Haors	450	3700
	Beels	177	1500
	Baors	55	560
	Ponds, tanks, ditches	3000	3500
	Kaptai Lake	563	740
3.	**Forest**	**19,610**	**19610**
	Sundarbans (land area)	4110	4110
	Coastline forest	1400	1400
	Hill forest	6000	6000
	Hill scrub and grass	6900	6900

No.	Classification	Dry Season (March)	Wet Season (September)
	Plain land forest and scrub	1200	1200
4.	**Cultivated**	**77,600**	**73500**
	Field crops	51000	17140
	Tree crops	4900	4900
	Seasonal fallow	17000	16760
	Current fallow	4100	4100
	Seedbed only	600	600
5.	**Brackish water aquaculture**	**1900**	**1900**
6.	**Salt beds**	**50**	**50**
7.	**Rural built-up**	**7000**	**7000**
	Homesteads	5500	5500
	Institutional	1500	1500
8.	**Non-cropped village land**	**8400**	**8400**
	Culturable waste	5800	5800
	Bamboo groves	1250	1250
	Forest and woodland	1350	1350
9.	**Urban**	**7000**	**7000**
10.	**Infrastructure**	**2100**	**2100**
11.	**Estuarine area**	**8600**	**8600**
Total		**147570**	**147570**

(Source: Banglapedia, 2003)

3.2.6 Coastal Zone of Bangladesh

The coast of Bangladesh is known as a zone of vulnerabilities as well as of opportunities. Bangladesh has a difficult coastline with many rivers and distributaries and complex ecology which is affected by natural hazards like cyclones, coastal flooding, tidal surges, salinity intrusion and climate change. Vulnerabilities in the coastal zone of Bangladesh are increasing with accentuations of natural hazards and sea level rise caused by various factors.

Three indicators have been considered for determining the landward boundaries of the coastal zone of Bangladesh. These are:

1. Influence of tidal waters,
2. Salinity intrusion and
3. Cyclones/storm surges

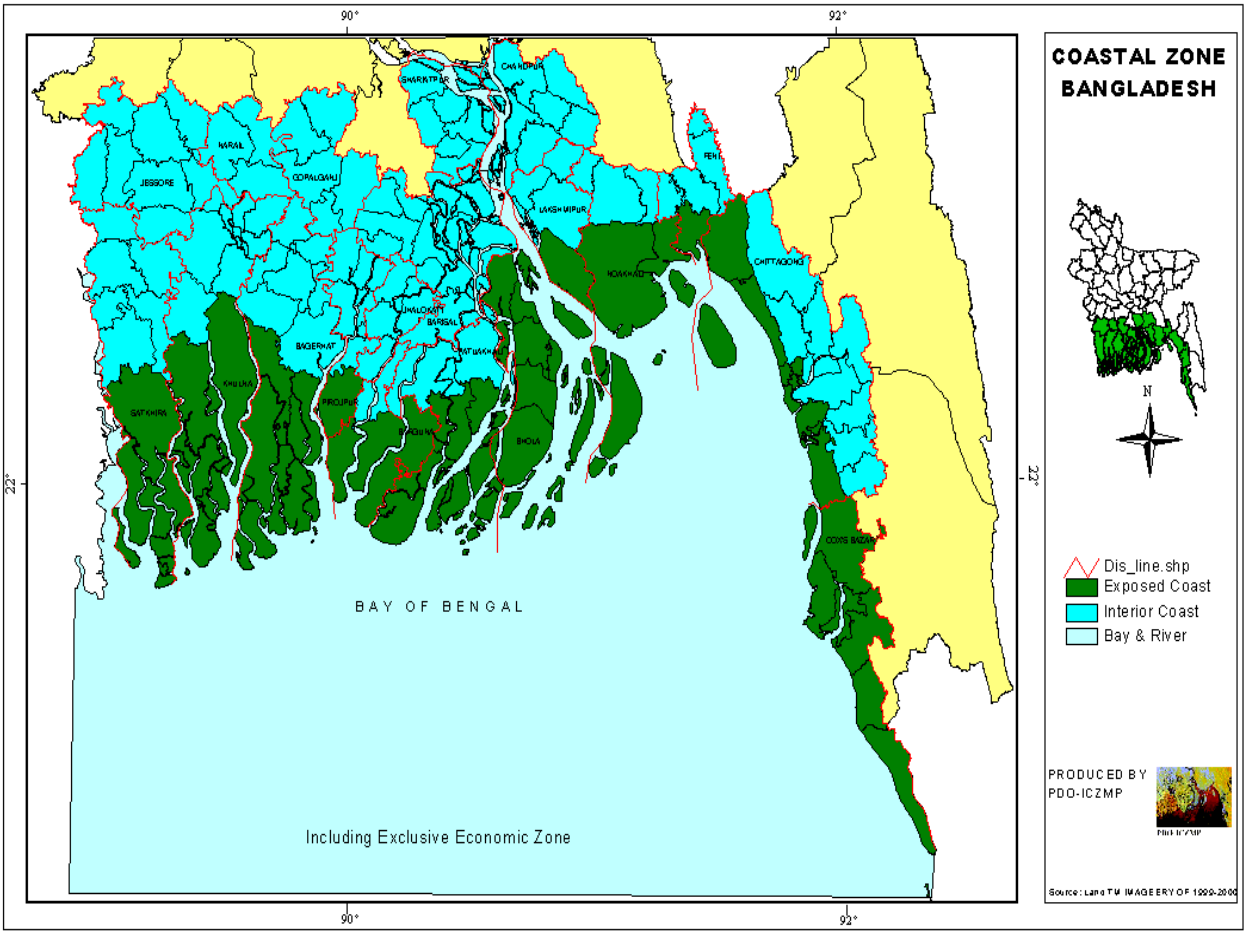


Figure 3.9: Coastal zone (Landward Boundary) of Bangladesh (Source: Coastal Zone Policy, 2005)

19 districts of the country are being affected directly or indirectly by some of these phenomena. The districts are considered including all upazilas/thanas. A total of 48 upazilas/thanas are considered as 'exposed' directly to vulnerabilities from natural disasters. The exclusive economic zone (EEZ) is regarded as the seaward coastal zone. One-third of the country belongs to the coastal zone. According to 2001 population census, population of the coastal zone is 3 crores and 48 lakhs. The country has a coastline of 710 km along the Bay of Bengal *(Coastal Zone Policy, 2005).* Major part of the coastal zone is covered by the deltas of the Ganges and the Meghna where the coastline is oriented along east-west direction. These

regions are crisscrossed by a network of interconnected distributaries and estuaries. The other part is covered by the Chittagong coastal plain bordered by hills, and the coastline is oriented along north-south direction. Most of the reversible wetlands considered in the classification system of wetlands of Bangladesh lie in the coastal zone.

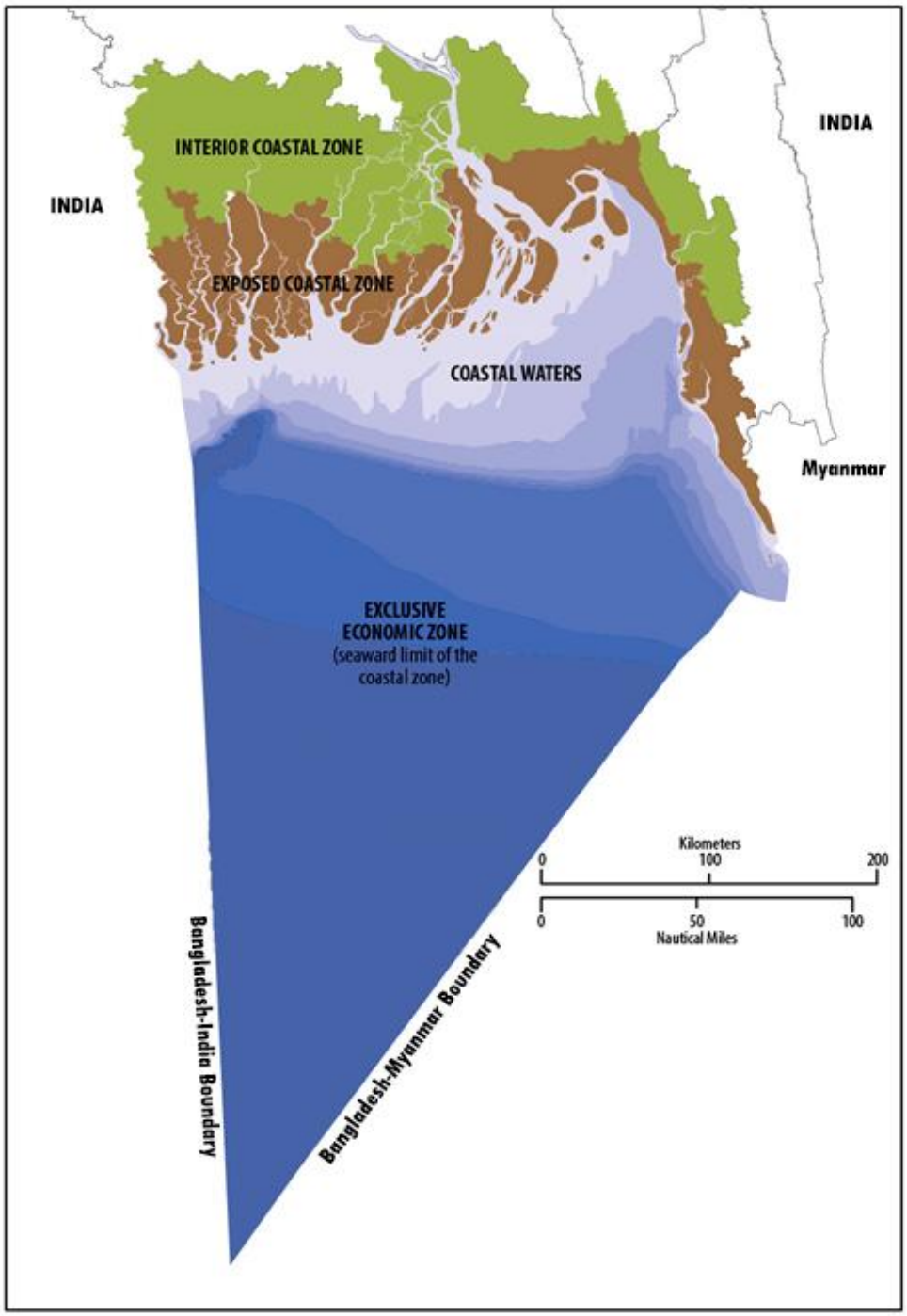


Figure 3.10: Coastal Zone (Seaward Boundary) of Bangladesh (Source: Chowdhury, 2015)

4 LITERATURE REVIEW

Various publications, documents and reports have been reviewed by the team in order to develop the classification system of wetlands of Bangladesh. These literatures help to better understand the diversified and complex characteristics of the wetlands of Bangladesh. Brief description of the literatures reviewed is given in the following sections. The sections may be considered as the excerpts of the respective documents.

4.1 Master Plan of Haor Areas, DBHWD, 2012

"Master Plan of Haor Areas" has been prepared by the Bangladesh Haor and Wetland Development Board (BHWDB), now renamed Department of Bangladesh Haor and Wetlands Development (DBHWD), during April 2012. The BHWDB engaged the Center for Environmental and Geographic Information Services (CEGIS), a Public Trust under the Ministry of Water Resources (MoWR) for preparing the Plan. It consists of 3 volumes- (Summary Report, Main Report and Project Portfolio) and 21 Annexures.

Haors are large bowl shaped floodplain depressions located in the north-eastern region of Bangladesh, in the districts of Sunamganj, Habiganj, Netrakona, Kishoreganj, Sylhet, Maulvibazar and Brahmanbaria. There are about 373 Haors that covers an area of about 858,000 ha which is about 43% of the total area of the Haor region (1.99 million ha). Details of the Haors are given the Annexure 2: Haors of Bangladesh.

Haors have a unique hydrological regime which creates opportunities as well as sufferings/constraints for the inhabitants of the Haor region. Annual rainfall ranges from 2200-5800 mm and can be as high as 12000 mm. Flash flood is the main disaster in this region that is caused by excess rainfall in the upstream hilly areas and subsequent runoff and sedimentation in the rivers.

The Haor region lies in the Meghna basin which is one of the largest Ganges-Brahmaputra-Meghna (GBM) basins. The total inflow in the haor area comes from India and along with the storm water runoff drains out through Meghna River at Bhairab Bazar. The rivers of the haor region are characterized by a natural alluvial system and are unstable by nature. The area becomes inundated during monsoon and sometimes in pre-monsoon by flash flood. Inflow from India is the main cause of flash flood in the Haor region. Floods are the characteristic of

the entire river system of the North East region. Embankments are utilized for flood protection in this region. Wetland condition ranges from perennial aquatic lowlands to seasonally dry uplands.

A variety of natural forest can be found in the Haor districts like hill forests, fresh water swamps, reed swap forests, cane and murta forest, bamboo and homestead vegetation etc. Ecologists have grouped the typical haor vegetation areas into nine classes, which are:

- Submerged plants,
- Free floating plants,
- Rooted floating plants,
- Sedges and meadows,
- Floodplain grassland,
- Reed swamp,
- Fresh water swamp forest,
- Crop field vegetation, and
- Homestead vegetation.

The biodiversity of haor wetlands is very rich. Water is central to the fragile ecosystem of the haor area. The most significant wetlands are Hakaluki Haor, Hail Haor, Tanguar Haor, Matian Haor, Pasuar Beel Haor, Dekar Haor, Baro Haor, Gurmar Haor, Sonamorol Haor, Baram Haor, Kalni Haor, Kawadighi Haor and Pagner Haor. These wetlands have a rich wildlife community including 257 species of birds, 40 species of reptiles, 29 species of mammal and 9 species of amphibians. The haor region comprises a wide variety of fin fish including 143 indigenous and 12 exotic species along with several species of freshwater prawns. The estimated fish habitat area in the haor region is about 967,000 ha. Most of the important haor areas are also enriched by wetland plants through lowland plantation.

The geological setting and formations of the northeastern part of Bangladesh favors the deposit of various types of mineral and energy resources. Mineral resources found in the Haor region are coal, crude oil, glass sand, gravel, lime stone, natural gas, peat, white clay. About 90% of the total gas production of the country is obtained from the Haor districts.

A six-step methodology was adopted for the preparation of the Master Plan. The framework for the planning process of the Master Plan included:

1. Identification of problems and issues,

2. Policy analysis for future directive,
3. Present status and environmental setting,
4. Review of past and ongoing development initiative,
5. Strategy for future development,
6. Formulation of plan

A whole range of problems and issues of Haors and wetlands have been identified and solutions to these problems have been derived considering individual, cross cutting and technical issues as well as the demand of the stakeholders. The main water related problems are flash flood, drainage congestion due to sedimentation and loss of connectivity between haor and rivers, river bank and wave erosion and poor navigability. The basin is under threat of encroachment by agriculture, deforestation and capture fisheries. The main purpose of the plan is to safeguard the water resources and to preserve the natural characteristics of the whole basin with special attention to ecologically important areas.

Different national policies and strategies have been thoroughly reviewed to set the main policy directives for the development of the Haor Master Plan. The National Water Policy explicitly mentions the development of the haor area considering its preservation of ecosystem.

The comprehensive Master Plan aims to preserve, protect and restore the eco-system as well as protect the people of this area from natural disasters and improve the livelihood of poor people. The Master Plan is a framework plan that is in line with the Vision 2021, Sixth Five Year Plan and other relevant policies and plans of the Government of Bangladesh. It is a 20-year plan formulated following the principles of the Integrated Water Resource Management (IWRM). The objectives are to develop the resources of the haor Region as rapidly as possible, to improve the overall quality of life of its inhabitants, maintaining and conserving the Haor ecosystem.

The Haor Master Plan will be implemented in three time frames, which are:

- Short Term: 1-5 years (from FY 2012-13 to FY 2016-17)
- Medium Term: 6-10 years (from FY 2017-18 to FY 2021-22)
- Long Term: 11-20 years (from FY 2022-23 to FY 2031-32)

The total estimated capital cost for the implementation of the Master Plan is BDT 2,796,305 lakh taka.

Development area wise strategies have been identified, evaluated and risk assessed for prioritization of the development areas. A total number of 154 projects has been proposed under 17 different development areas. 38 Government agencies and 16 different Ministries are associated with the implementation of the plan. The projects has to be monitored regularly during implementation and evaluation should be done by examining their objectives at both pre and post project levels and should be updated every 5 years.

4.2 The Ramsar Convention Manual, 1971

The Convention on Wetlands is an Intergovernmental Treaty whose mission is "the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world". The Convention was adopted on 2 February 1971 in the Iranian city of Ramsar, on the southern shore of the Caspian Sea. The name of the Convention is usually written "Convention on Wetlands (Ramsar, Iran, 1971)", and is popularly known as the "Ramsar Convention".

The Convention entered into force in 1975 and now (as of July 2016) has 169 Contracting Parties, or member States, in all parts of the world. Though the central Ramsar message is the need for the sustainable use of all wetlands, the "flagship" of the Convention is the List of Wetlands of International Importance (the "Ramsar List") – presently, the Parties have designated for this List more than 2,060 wetlands for special protection as "Ramsar Sites", covering 197 million hectares (1.97 million square kilometers).

The Ramsar Convention takes a broad approach in determining the wetlands which come under its mandate. As also mentioned earlier, for this study, definition of wetlands of Ramsar Convention has been adopted (Section 1.1).

The Ramsar Classification of Wetland Type includes 42 types of wetlands, grouped into three categories:

- Marine and Coastal Wetlands
- Inland Wetlands
- Human-made Wetlands

There are 12 types of wetlands listed under the Marine and Coastal Wetlands class, 20 under Inland Wetlands class and 10 under the Human-made Wetlands class. The classification is shown in table 4.1.

Table 4.1: Ramsar Classification of Wetlands

	Name of Classification Type
Marine/Coastal Wetlands	A -- Permanent shallow marine waters in most cases less than six metres deep at low tide; includes sea bays and straits
	B -- Marine subtidal aquatic beds; includes kelp beds, sea-grass beds, tropical marine meadows
	C -- Coral reefs
	D -- Rocky marine shores; includes rocky offshore islands, sea cliffs
	E -- Sand, shingle or pebble shores; includes sand bars, spits and sandy islets; includes dune
	F -- Estuarine waters; permanent water of estuaries and estuarine systems of deltas
	G -- Intertidal mud, sand or salt flats
	H -- Intertidal marshes; includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal brackish and freshwater marshes
	I -- Intertidal forested wetlands; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests
	J -- Coastal brackish/saline lagoons; brackish to saline lagoons with at least one relatively narrow connection to the sea
	K -- Coastal freshwater lagoons; includes freshwater delta lagoons
	Zk(a) – Karst and other subterranean hydrological systems, marine/coastal

Inland Wetlands	L -- Permanent inland deltas
	M -- Permanent rivers/streams/creeks; includes waterfalls
	N -- Seasonal/intermittent/irregular rivers/streams/creeks
	O -- Permanent freshwater lakes (over 8 ha); includes large oxbow lakes
	P -- Seasonal/intermittent freshwater lakes (over 8 ha); includes floodplain lakes
	Q -- Permanent saline/brackish/alkaline lakes
	R -- Seasonal/intermittent saline/brackish/alkaline lakes and flats
	Sp -- Permanent saline/brackish/alkaline marshes/pools
	Ss -- Seasonal/intermittent saline/brackish/alkaline marshes/pools
	Tp -- Permanent freshwater marshes/pools; ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season
	Ts -- Seasonal/intermittent freshwater marshes/pools on inorganic soils; includes sloughs, potholes, seasonally flooded meadows, sedge marshes
	U -- Non-forested peatlands; includes shrub or open bogs, swamps, fens
	Va -- Alpine wetlands; includes alpine meadows, temporary waters from snowmelt
	Vt -- Tundra wetlands; includes tundra pools, temporary waters from snowmelt
	W -- Shrub-dominated wetlands; shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils
	Xf -- Freshwater, tree-dominated wetlands; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils
	Xp -- Forested peatlands; peatswamp forests
	Y -- Freshwater springs; oases
	Zg -- Geothermal wetlands
	Zk(b) – Karst and other subterranean hydrological systems, inland
Human-made Wetlands	1 -- Aquaculture (e.g., fish/shrimp) ponds
	2 -- Ponds; includes farm ponds, stock ponds, small tanks; (generally below 8 ha)
	3 -- Irrigated land; includes irrigation channels and rice fields
	4 -- Seasonally flooded agricultural land (including intensively managed or grazed wet meadow or pasture)
	5 -- Salt exploitation sites; salt pans, salines, etc
	6 -- Water storage areas; reservoirs/barrages/dams/impoundments (generally over 8 ha)
	7 -- Excavations; gravel/brick/clay pits; borrow pits, mining pools
	8 -- Wastewater treatment areas; sewage farms, settling ponds, oxidation basins, etc
	9 -- Canals and drainage channels, ditches

Each site is designated with a specific code to identify the type of wetland and their characteristics. The codes are based upon the Ramsar Classification System for Wetland Type as approved by Recommendation 4.7 and amended by Resolutions VI.5 and VII.11 of the Conference of the Contracting Parties *(Ramsar, 1971).* The criteria for declaration of Ramsar sites have been given in Box 4.1.

Criteria for the designation of Wetlands of International Importance

Criterion 1	A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
Criterion 2	A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
Criterion 3	A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
Criterion 4	A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
Criterion 5	A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.
Criterion 6	A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.
Criterion 7	A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/ or values and thereby contributes to global biological diversity.
Criterion 8	A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
Criterion 9	A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

Box 4.1: Criteria for the designation of Wetlands of International Importance (Source: The Ramsar Convention Manual, 2013)

4.3 FGDC Classification of Wetlands and Deepwater Habitats, 1996

Classification of Wetlands and Deepwater Habitats of the United States has been prepared by Federal Geographic Data Committee (FGDC) as a National Standard in 1996. Classification of Wetlands and Deepwater Habitats of the United States, as originally drafted by Cowardin et al. (1979), was "to impose boundaries on natural ecosystems for the purposes of inventory, evaluation, and management." The classification is hierarchical, progressing from System and Subsystems at the most general levels to Classes and Subclasses.

System: The term System refers to wetlands that share the influence of similar hydrologic, geomorphologic, chemical and biological factors. By this factors wetlands are divided into five systems and they are Marine, Estuarine, Riverine, Lacustrine, and Palustrine.

1. **Marine System**

   The Marine System consists of the open ocean overlying the continental shelf and its associated high-energy coastline. Marine habitats are exposed to the waves and currents of the open ocean and the Water Regimes are determined primarily by the ebb and flow of oceanic tides. Salinity exceeds 30 parts per thousand (ppt), with little or no dilution except outside the mouths of estuaries.

2. **Estuarine System:**

   The Estuarine System consists of deep-water tidal habitat and adjacent wetlands that are usually semi enclosed by land but have open, partly obstructed, or sporadic access to the open ocean in which ocean water is at least occasionally diluted by fresh water runoff from the land.

3. **Riverine System**

   The Riverine System includes all wetlands and deepwater habitats contained within a channel, with two exceptions: wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and habitats with water containing ocean-derived salts of 0.5 ppt or greater. A channel is an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water.

4. **Lacustrine System**

   The Lacustrine System includes wetlands and deepwater habitats with all of the following characteristics: situated in a topographic depression or a dammed river

channel; lacking trees, shrubs, persistent emergents, emergent mosses or lichens with 30 percent or greater areal coverage; and total area of at least 8 hectares.

5. **Palustrine System**

   The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergent, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 ppt. Total area of wetlands are below 8 hectares.

Subsystem: Every System is then divided into subsystems except Palustrine. Marine and Estuarine Systems are divided into two Subsystems based on Tide. And they are Subtidal and Intertidal. Riverine system is divided into four Subsystems depending on the Tidal influence, gradient, substrate and extent of floodplain development. They are: Tidal, Lower Perennial, Perennial, Upper Perennial and Intermittent. These Subsystems also have characteristic flora and fauna. Lacustrine System is divided into two Subsystems depending on the depth below low water; they are Limnetic and Littoral.

1. **Marine System and Estuarine System**
   a. **Subtidal:** The substrate in this habitat is continuously covered with tidal water.
   b. **Intertidal:** The substrate in this habitat is flooded and exposed by tides.
2. **Riverine System**
   a. **Tidal:** This Subsystem extends from the upstream limit of tidal fluctuations down to the upper boundary of the Estuarine System, where the concentration of ocean-derived salt reaches 0.5 ppt during the period of average annual low flow. The gradient is low and water velocity fluctuates under tidal influence.
   b. **Lower Perennial:** This Subsystem is characterized by a low gradient. There is no tidal influence, and some water flows all year, except during years of extreme drought. The substrate consists mainly of sand and mud. Oxygen deficits may sometimes occur. The fauna is composed mostly of species that reach their maximum abundance in still water, and true planktonic organisms are common. The gradient is lower than that of the Upper Perennial Subsystem and the floodplain is well developed.
   c. **Upper Perennial:** This Subsystem is characterized by a high gradient. There is no tidal influence, and some water flows all year, except during years of

extreme drought. The substrate consists of rock, cobbles, or gravel with occasional patches of sand. The natural dissolved oxygen concentration is normally near saturation. The fauna is characteristic of running water, and there are few or no planktonic forms. The gradient is high compared with that of the Lower Perennial Subsystem, and there is very little floodplain development.

d. **Intermittent:** This Subsystem includes channels that contain flowing water only part of the year. When the water is not flowing, it may remain in isolated pools or surface water may be absent.

3. **Lacustrine System**
   a. **Limnetic:** This subsystem includes all deepwater habitats in the Lacustrine System.
   b. **Littoral:** This subsystem includes all wetland habitats in the Lacustrine System.
4. **Palustrine System:**
   This system does not have any subsystems.

Classes: The Class is the highest taxonomic unit below the Subsystem level. It describes the general appearance of the habitat in terms of either the dominant life form of the vegetation or the physiography and composition of the substrate—features that can be recognized without the aid of detailed environmental measurements. The different classes are:

1. **Rock Bottom:** Substrates with areal cover of stones, boulders or bedrock is 75% or greater and vegetative cover is less than 30%.
2. **Unconsolidated Bottom:** 25% cover of particles is smaller than stones and vegetative cover less than 30%
3. **Aquatic Bed:** The Class “Aquatic Bed” includes wetlands and deepwater habitats where plants that grow principally on or below the surface of the water (i.e., surface plants or submergents) are the uppermost life form layer with at least 30 % areal coverage.
4. **Reef:** The Class Reef includes ridge-like or mound-like structures formed by the colonization and growth of sedentary invertebrates.
5. **Streambed:** The Class Streambed includes all wetlands contained within the Intermittent Subsystem of the Riverine System and all channels of the Estuarine

System or of the Tidal Subsystem of the Riverine System that are completely dewatered at low tide.

6. **Rocky Shore:** Characterized by bedrock, stones, or boulders which singly or in combination have an aerial cover of 75 % or more and an aerial coverage by vegetation of less than 30 %.
7. **Unconsolidated Shore:** Unconsolidated substrates with less than 75 percent areal cover of stones, boulders, or bedrock; (2) less than 30 percent areal cover of vegetation other than pioneer plants; and (3) any of the following Water Regimes: Irregularly Exposed, Regularly Flooded, Irregularly Flooded, Seasonally Flooded, Seasonally Flooded Saturated, or Temporarily Flooded, Intermittently Flooded, Regularly Flooded Tidal Fresh, Seasonally Flooded-Tidal Fresh, or Temporarily Flooded-Tidal Fresh.
8. **Moss-Lichen Wetlands:** Where mosses or lichens cover at least 30 percent of substrates other than rock and where emergents, shrubs, or trees alone or in combination cover less than 30 percent.
9. **Emergent Wetlands:** Emergent plants i.e., erect, rooted, herbaceous hydrophytes, excluding mosses and lichens are the tallest life form with at least 30% areal coverage. This vegetation is present for most of the growing season in most years.
10. **Scrub-Shrub Wetlands:** Woody plants less than 6 m (20 ft) tall are the dominant life form i.e., the tallest life form with at least 30 percent areal coverage.
11. **Forested Wetlands:** The tallest life form with at least 30 percent areal coverage. Trees are defined as woody plants at least 6m (20 ft) in height.

Subclasses and Dominance Types:

Finer distinctions in life forms are recognized at the Subclass level. Subclasses are named on the basis of the specific life form with the greatest areal coverage. The subclasses are:

1. **Bedrock:** Bottoms in which bedrock covers 75 percent or more of the surface
2. **Rubble:** Bottoms with less than 75 percent areal cover of bedrock, but stones and boulders alone, or in combination with bedrock, cover 75 percent or more of the surface
3. **Cobble-Gravel:** The unconsolidated particles smaller than stones are predominantly cobbles and gravel, although finer sediments may be intermixed.
4. **Sand:** The unconsolidated particles smaller than stones are predominantly sand, although finer or coarser sediments may be intermixed.

5. **Mud:** The unconsolidated particles smaller than stones are predominantly silt and clay, although coarser sediments or organic material may be intermixed. Organisms living in mud must be able to adapt to low oxygen concentrations.
6. **Organic:** The unconsolidated material smaller than stones is predominantly organic; there is no minimum depth requirement. The organic material is dead plant tissue in varying stages of decomposition.
7. **Algal:** In these Aquatic Beds, algae have the greatest areal coverage. Algal Beds are widespread and diverse in the Marine and Estuarine Systems, where they occupy substrates characterized by a wide range of sediment depths and textures. They occur in both the Subtidal and Intertidal Subsystems and may grow to depths of 30 m.
8. **Aquatic Moss:** In this Subclass, aquatic mosses have the greatest areal coverage. Aquatic mosses are far less common than algae or vascular plants. Aquatic Moss Beds occur primarily in the Riverine System and in Permanently Flooded and Intermittently Exposed parts of some lacustrine systems.
9. **Rooted Vascular:** In this Subclass, rooted vascular plants have the greatest areal coverage. In the Marine and Estuarine Systems, Rooted Vascular Beds include a large array of species that grow primarily below water.
10. **Floating Vascular:** In this Subclass, vascular plants that float freely on or below the water surface have the greatest areal coverage. Floating Vascular Beds occur mainly in the Lacustrine, Palustrine, and Riverine Systems and in the less saline waters of the Estuarine System.
11. **Coral:** Coral Reefs are widely distributed in shallow waters of warm seas. Coral Reefs lie almost entirely within the Subtidal Subsystem of the Marine System,
12. **Mollusk:** This Subclass occurs in both the Intertidal and Subtidal Subsystems of the Estuarine System. These Reefs are found on the Pacific, Atlantic, and Gulf Coasts and in Hawaii and the Caribbean.
13. **Worm:** Worm Reefs are constructed by large colonies of Sabellariid worms living in individual tubes constructed from cemented sand grains. Although they do not support as diverse a biota as do Coral and Mollusk Reefs, they provide a distinct habitat which may cover large areas.
14. **Vegetated:** These Streambeds are exposed long enough to be colonized by pioneer plants that, unlike Emergent Wetland plants or Scrub-Shrub Wetland plants, are usually killed by rising water levels.

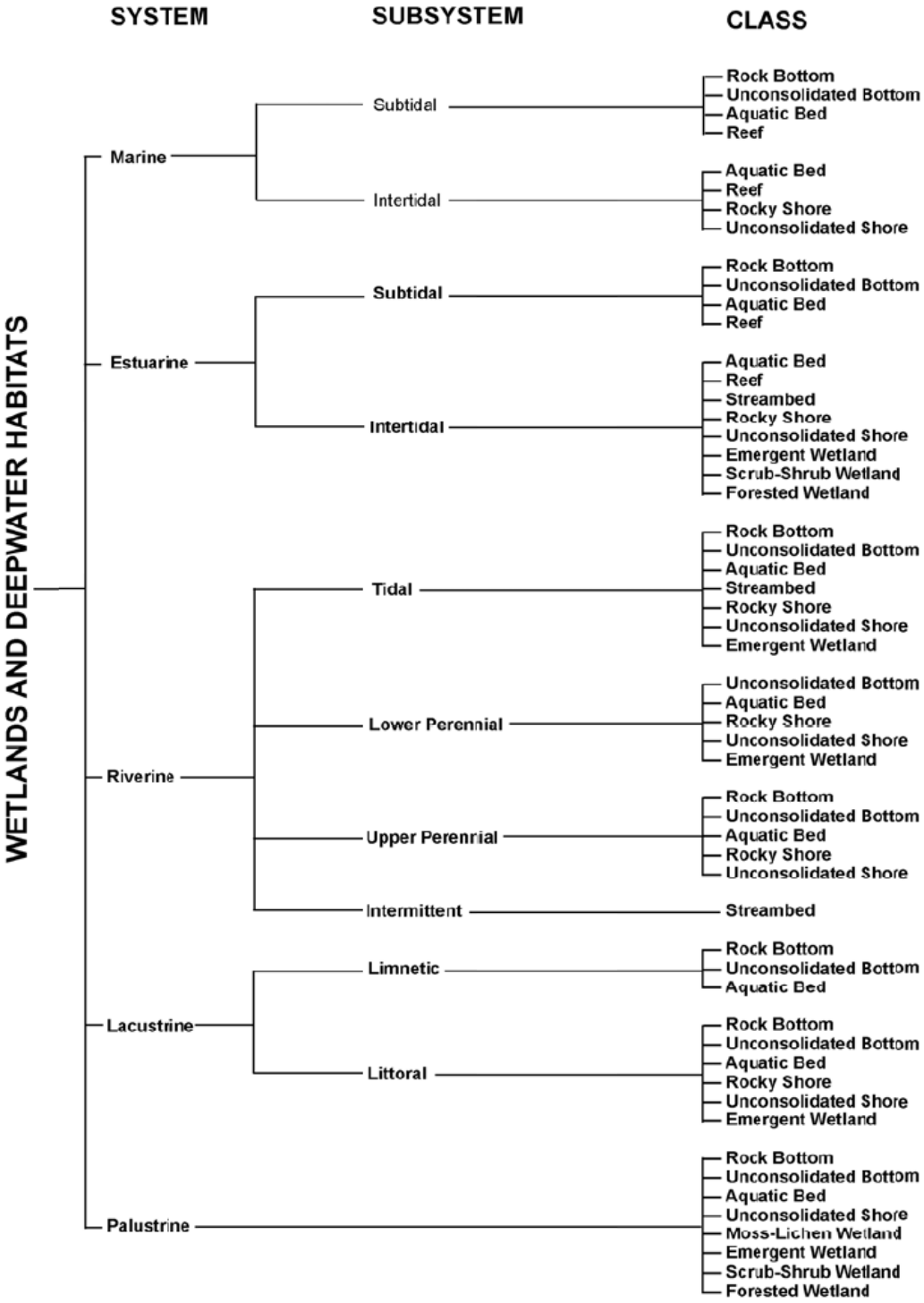
15. **Organic:** This Subclass is characterized by channels formed in peat or muck. Organic Streambeds are common in the small creeks draining Estuarine Emergent Wetlands with organic soils.
16. **Moss:** In this Subclass, the areal coverage of mosses exceeds that of lichens.
17. **Lichen:** In this Subclass, the areal coverage of lichens exceeds that of mosses.
18. **Persistent:** In this Subclass, the areal coverage of persistent emergents exceeds that of nonpersistent emergents. Persistent emergents are emergent hydrophytes whose stems and leaves are evident all year above the surface of the water, or above the soil surface if water is absent. Persistent Emergent Wetlands occur only in the Estuarine and Palustrine Systems.
19. **Non-Persistent:** In this Subclass, the areal coverage of nonpersistent emergents exceeds that of persistent emergents.
20. **Broad-leaved Deciduous:** In this Subclass, broad-leaved deciduous species have the greatest areal coverage within the shrub layer.
21. **Broad-leaved Evergreen:** In this Subclass, broad-leaved evergreen species have the greatest areal coverage within the shrub layer.
22. **Needle-leaved Deciduous:** In this Subclass, needle-leaved deciduous species have the greatest areal coverage within the shrub layer.
23. **Needle-leaved Evergreen:** In this Subclass, needle-leaved evergreen species have the greatest areal coverage within the shrub layer.

Modifiers: To fully describe wetlands and deepwater habitats, one must apply certain Modifiers to the classification hierarchy. The Modifiers described were adapted from existing classifications or were developed specifically for this classification system. The modifiers are:

1. **Water Regime Modifier:** Tidal Salt, Nontidal, Tidal Fresh
2. **Water Chemistry Modifier:** Salinity Modifier and pH Modifier.
3. **Soil Modifier:** Depth, Mineral Composition, Organic Matter Count, Moisture Regime, Temperature Regime and Chemistry.
4. **Special Modifiers:** Beaver, Partly Drained/Ditched, Farmed, Excavated, Diked/Impounded, Artificial Substrate, Spoil.

The FGDC Classification System of Wetlands is given in Table 4.2.

Table 4.2: FGDC Classification System of Wetlands



4.4 National Wetland Inventory & Assessment (India), 2013

National Wetland Inventory & Assessment (NWIA) was published as a joint programme of Ministry of Environment & Forests, Government of India, and Space Applications Centre, ISRO, Ahmedabad in March, 2013. This report deals with the updated database and status of wetlands, compiled in Atlas format. The atlas comprises wetland information arranged into five sections. The wetlands are categorized under 19 classes and mapped using satellite remote sensing data from Indian Remote Sensing Satellite: IRS P6- LISS III sensor. The results are organized at 1: 50, 000 scales at district, state and topographic map sheet (Survey of India reference) level using Geographic Information System (GIS). This publication is a part of this national work and deals with the wetlands of India that are internationally important under Ramsar Convention, narrated through text, statistical tables, satellite images, maps and ground photographs. The main objectives of the project are quoted below:

“

- *Wetland mapping and inventory at 1: 50 000 scale by analysis of digital IRS LISS III data of post and pre-monsoon seasons.*
- *Creation of digital database in GIS environment.*
- *Preparation of State-wise wetland atlases”*

The methodology highlights how the four spectral bands of LISS III data (green, red, near infra-red and short wave infra-red) have been used to derive various indices and understand information regarding water spread, turbidity and aquatic vegetation. As the aim was to generate a spatial database; details of the standards of database are also highlighted in the methodology. The Maps and Statistics are shown for each site and gives details area estimates. Since, the hydrology of wetlands is influenced by monsoon performance, extent of water spread and their turbidity (qualitative) in wet and dry season (post- monsoon and pre-monsoon period) are also given. Similarly, the status of aquatic vegetation (mainly floating and emergent types) in two seasons is also accounted for.

As mentioned earlier, Wetlands in India have been categorized in 19 classes. The broad frame work for inclusion of wetland classes follows the definition devised under the Ramsar Convention. 19 wetland classes are organized under a Level III hierarchical system. Level one has two wetland classes: inland and coastal, these are further bifurcated into two categories as: natural and man-made under which all the wetlands occurring in India are suitably placed. Wetlands put to agricultural use in any time of the year were not considered

for mapping in this project. The classification system is given below in Table 4.3. NNRMS (National Natural Resources Management System) standards were followed to create the NWIA data base.

Table 4.3: Wetlands Classification System of India (NWIA)

Wettcode*	Level I	Level II	Level III
1000	**Inland Wetlands**		
1100		Natural	
1101			Lakes
1102			Ox-Bow Lakes/ Cut-off Meanders
1103			High altitude Wetlands
1104			Riverine Wetlands
1105			Waterlogged
1106			River/stream
1200		Man-made	
1201			Reservoirs/ Barrages
1202			Tanks/Ponds
1203			Waterlogged
1204			Salt pans
2000	**Coastal Wetlands**		
2100		Natural	
2101			Lagoons
2102			Creeks
2103			Sand/Beach
2104			Intertidal mud flats
2105			Salt Marsh
2106			Mangroves
2107			Coral Reefs
2200		Man-made	
2201			Salt pans
2202			Aquaculture ponds

[Source: Space Application Centre, India, 2013]

The findings of NWIA are:

- Entire country including the main land and islands territories has been considered for inventory and assessment of wetlands.
- Total wetland area estimated as 15.260 Mha, which is around 4.63 per cent of the geographic area of the country.
- Total 201503 wetlands have been mapped at 1:50,000 scale. In addition, 555557 small wetlands (<2.25 ha) have also been identified.
- Excluding rivers/streams, the total wetland area estimated to be 10 Mha.
- Inland-Natural wetlands accounted for around 43.4 per cent of the total area, while Coastal-Natural wetlands account for 24.3 per cent.
- Aquatic vegetation is observed in lake/pond, riverine wetland, ox-bow lake, tank/pond and reservoir. The aquatic vegetation in wetlands (floating and emergent) is more during pre-monsoon (14 %) than during post-monsoon (9 %).
- The qualitative turbidity of water in wetlands is low in 37.3% areas, moderate in 48.5% and high in 14.2% area in post-monsoons season. During pre-monsoon season low turbidity was observed in 32.6% area, moderate turbidity in 51.1% and high turbidity in16.3% area.

4.5 Vietnamese Wetlands Classification System, 2008

The Vietnamese Wetlands Classification System (VWCS) is an important basis for identification of wetlands of international and national importance in order to encourage their designation and appropriate long term management. The VWCS is to be used by Vietnamese Government Agencies, NGOs and scientists. The classification also serves as a broad framework to aid the rapid identification of the main wetland habitats represented at each site, to provide units for mapping, and to encourage uniformity of concepts and terms in national wetland inventory of Vietnam.

The Vietnamese Wetlands Classification System was formulated based on wetland classification system of Ramsar. It has also considered system proposed by Mekong River Committee, IUCN, countries (such as Canada, the United States, and Japan), and other Vietnamese authors. The Vietnamese Wetlands Classification System is a hierarchy of systems, subsystems, classes, and types or sub-types of wetlands. The systems are defined based on salinity of water or distance of wetland from the sea - marine/coastal wetland

(salty/brackish wetlands) and inland wetland (freshwater wetlands). The subsystems are based on the main origin of wetlands – natural or artificial wetlands. The classes are defined based on the hydrological regime; they would be permanent or non-permanent (covered by water) wetlands. The types are defined based not only on geomorphologic, geologic features and origin of wetlands, but also the dominant life form of vegetation or physiography and composition of substrate features. There are 38 wetland types defined in the classification system. The classification System is shown in Table 4.4.

In the classification hierarchy, the term ″system″ refers to a collection of wetlands that share the influence of the salinity of water and marine factors. Systems are further divided into subsystems based on main origin of wetlands, due to natural processes and human activities (artificial). The ″class″ is the highest taxonomic unit below the sub-system level. The class is determined based on the hydrological condition (permanent and non-permanent). Under class in Vietnamese Wetlands Classification System is the ″type″. The type describes general appearance of the habitat in the terms of the either dominant life form of vegetation or physiography and composition of substrate features, geomorphologic, geologic features and origin of wetland, which can be recognized without any environment measurement. For every type, a symbol has been allotted. Table 4.4 also shows both the VWCS types and corresponding Ramsar types of wetlands.

Table 4.4: Wetlands Classification System of Vietnam

Systems	Sub-systems	Classes	Types		
			Symbols		Name of wetland types
			Vietnam	Ramsar	
Marine/coastal wetland (salty/brackish wetlands)	1.1. Natural wetlands	1.1.1. Permanent	Vb	Aa	1. Permanent shallow marine waters less than six meters deep at low tide
			Vv		2. Gulfs and bays
			Tv	B	3. Marine sub-tidal aquatic beds, includes kelp beds, sea-grass beds, tropical marine meadows
			Sh	C	4. Coral reefs
			Dp	J	5. Lagoons
			Cs	F	6. Estuaries
			Cns[l]	Fa	7. Submerged estuarine sandy islets
		1.1.2. Non-permanent	Cbs	Fb	8. Estuarine barrier islands
			BD	D	9. Rocky marine shores, includes rocky offshore islands, sea cliffs, benches
			Bc	Ea	10. Beaches
			Bcs	Eb	11. Intertidal shingle or pebble shores
			Bcb	Ga	12. Intertidal muddy sand shores
			Bbc	Gb	13. Intertidal sandy mud shores
			R	I	14. Mangrove forests
			Dl	H	15. Intertidal marshes
			Kb	Zk(a)	16. Marine/coastal karsts and other subterranean hydrological systems,
	1.2. Artificial wetlands	1.2.1. Permanent	Tl	1a	17. Salty/brackish aquaculture ponds
			Tvk	10	18. Sedge farms
		1.2.2. Non-permanent	Tlk	2	19. Aquaculture tidal flats
			Mu	5	20. Salt exploitation sites
Inland wetland (freshwater wetlands)	2.1. Natural wetlands	2.1.1. Permanent	S	M	21. Permanent rivers/streams/creeks
			H	O	22. Permanent freshwater lakes (over 8 ha)
			D	Tp	23. Permanent freshwater marshes/pools (below 8 ha)
			O	Y	24. Freshwater oases
			Nk	Zg	25. Geothermal wetlands, hot springs, mineral springs
		2.1.2. Non-permanent	Sk	N	26. Seasonal/intermittent/irregular rivers/streams/creeks
			Tb	U	27. Non-forested peatlands
			Tbr	Xp	28. Forested peatlands
			Cl	Xf	29. Freshwater, tree-dominated wetlands
			Cn	Ts	30. Seasonal/intermittent freshwater marshes/pools
			Cb	W	31. Shrub-dominated wetlands
			Kn	Zk(b)	32. Karsts and other subterranean hydrological systems, inland
	2.2. Artificial wetlands	2.2.1. Permanent	Tn	1b	33. Freshwater aquaculture ponds
			Km	3a	34. Channels, canals
			Tr	6	35. The other water storage areas
			X	8	36. Wastewater treatment areas
		2.2.2. Non-permanent	Nn	3b	37. Cultivated wetlands
			Mo	7	38. Excavations, mining pools

[Source: Nhuan et al., 2008]

4.6 Coastal Zone Policy, 2005

Bangladesh is a country which faces natural hazards almost on every season. The fact is more applicable for the coastal zones lying on the southern side of the country. The country has a coastline of 710 km along the Bay of Bengal. The coast of Bangladesh is known as a zone of vulnerabilities as well as opportunities like high potential for exploitation of both onshore and offshore natural gas. It is prone to natural disasters like cyclone, storm surge and flood. The combination of natural and man-made hazards, such as erosion, high arsenic content in ground water, water logging, earthquake, water and soil salinity, various forms of pollution, risks from climate change, etc. have adversely affected lives and livelihoods in the coastal zone. The coast also contains several ecosystems that have important conservation values. The coastal zone has not only biodiversity hot spots, but also provides the ecological foundation for an important common property resource; a large portion of these resources is various types of fisheries of the Bay of Bengal. Increasing population, competition for limited resources, natural and man-made hazards, lack of economic opportunities, important ecological hot spots, etc, calls for distinctive coastal management. The Government of Bangladesh realizes this need, and special reference to coastal issues has been repeatedly made in government policies.

The Government considered the following three reasons for initiating the coastal zone policy:

“

a) *The coastal zone is lagging behind in socio-economic developments on many aspects;*
b) *Poor initiatives to cope with different disasters and gradual deterioration of the environment;*
c) *The coastal zone has the potential to contribute much to national development.”*

Three indicators have been considered for determining the landward boundaries of the coastal zone of Bangladesh. These are: influence of tidal waters, salinity intrusion and cyclones/storm surges. The coastal zone covers 19 districts, 13 facing or having proximity to the Bay of Bengal and the Exclusive Economic Zone (EEZ). The coastal districts are Bagerhat, Barguna, Barisal, Bhola, Chandpur, Chittagong, Cox’s Bazar, Feni, Gopalganj, Jessore, Jhalkati, Khulna, Lakshmipur, Narail, Noakhali, Patuakhali, Pirojpur, Satkhira and Shariatpur. The districts are considered including all upazilas/thanas. A total of 48 upazilas/thanas are considered as exposed coast including all chars and more than 70 islands,

which face directly the vulnerabilities of above mentioned natural disasters. The exclusive economic zone (EEZ) is regarded as the seaward coastal zone. The map of the coastal zone is given in Chapter 3, in Figure 3.9. One-third of the country belongs to the coastal zone. According to 2001 population census, population of the coastal zone is 3 crores and 48 lakhs. The Government declares its intention of integrated coastal zone management following the principles of coastal zone policy. Following this policy, all concerned Ministries, Agencies, Local Government Institutions, NGOs, private sector and the civil society will put their efforts for the development of the coastal zone.

Goal: The coastal development process aims to meet, on an overall basis, National Goal for Economic Growth, Poverty Reduction & Social Development; Code of Conduct for Responsible Fisheries, Code of Conduct for Responsible Mangrove Management and other international conventions and treaties including to achieve the targets of the Millennium Development Goals (MDGs). The goal of integrated coastal zone management is:

> *"to create conditions, in which the reduction of poverty, development of sustainable livelihoods and the integration of the coastal zone into national processes can take place."*

Policy Framework: The Government has made the Coastal Zone Policy statement in relation to the following development objectives:

1. **Economic growth**

   Effective measures will be taken to realize the objectives of poverty reduction through enhancing economic growth in the coastal zone. There are 9 policy directives.

2. **Basic needs and livelihood opportunities**

   The coastal zone is also lagging behind in some key areas like providing basic needs of the coastal people and enhance livelihood opportunities. Coastal Zone Policy addresses these problems and tries to meet the demand. There are 13 policy directives.

3. **Reduction of vulnerabilities**

   Disasters like cyclone, drainage congestion, land erosion and drought that take toll on life and property and depletion of natural resource base that supports particularly

the poor are typical to the coastal zone. Majority households are vulnerable to climate change. In the coastal zone, agriculture continues to be a major source of employment, which is most vulnerable to natural hazards. The Policy makes it an integral part to reduce vulnerability to natural disasters and to enhance the coping capacity. There are 10 policy directives.

4. **Sustainable management of natural resources**

   Another important aspect of the Coastal Zone Policy is to ensure sustainable management of both biotic and abiotic coastal resources. Coastal zone is full of diverse natural resources: inland fisheries & shrimp, marine fisheries, mangrove and other forests, land, livestock, salt, minerals, sources of renewable energy like tide, wind and solar energy. So it is important to take suitable measures for sustainable use of renewable resources and ensuring sustainable use of coastal resources. There are 6 major policy directives for land resources, water resources, fisheries, aquaculture, agriculture, livestock, afforestation and energy.

5. **Equitable distribution**

   Different kinds of social, economic, technical or institutional barriers limit access of the poor people to these resources and opportunities. Due to ineffective access mechanism, the disadvantaged cannot get access to the basic needs. To ensure right of the neglected and disadvantaged groups, Government policy is to design actions to reach the poorest and to the remote rural areas. There are 4 policy directives.

6. **Empowerment of communities**

   Mainstreaming of the coastal people will be done by enhancing their safety and capacity. In their context, there are 6 policy directives.

7. **Women's development and gender equality**

   The national development strategy of the Government clearly states the importance of women's development and gender gap as a developing objective. There are 6 policy directives.

8. **Conservation and enhancement of critical ecosystem**

   Necessary measures will be taken to conserve and develop aquatic and terrestrial including all the ecosystems of importance identified by the *Bangladesh National Conservation Strategy* (Mangrove, coral reef, tidal wetland, sea grass bed, barrier island, estuary, closed water body, etc.). Implementation of all laws for the protection of all special areas will be ensured for environmental balance. There are 18 policy directives. The specific areas are:

- Conserving the ecosystem
- Pollution control and
- Climate change

9. **Enabling institutional environment**
    - **Mainstreaming coastal for management**
    - **Strategic plan and programme development**
    - **Coordination**
    - **Supporting Activities**

      Measures will be taken to formulate an appropriate institutional framework and to enact necessary laws and regulations in order to harmonize and coordinate all development activities in the coastal zone. A Coastal Development Strategy for poverty reduction, economic growth and social development will be formulated and implemented. Implementation will be the responsibility of the respective Ministries and the agencies.
    - **Legislative framework**

      In order to strengthen enabling institutional environment, some supporting activities have been identified such as Coastal Resources Survey, setup Integrated Coastal Resources Database etc. The Coastal Zone Policy may be revised if and where it becomes necessary.

4.7 National Water Policy, 1999

The Government of Bangladesh declared the National Water Policy in 1999. It recognizes that water is central to the way of life in Bangladesh and the single-most important resource for the well-being of its people. It sustains an extremely fragile natural environment and provides livelihood for millions of people. Water resources management in Bangladesh faces immense challenge for resolving many diverse problems and issues. The most critical of these are alternating flood and water scarcity during the wet and the dry seasons, ever-expanding water needs of a growing economy and population, and massive river sedimentation and bank erosion. There is a growing need for providing total water quality management (checking salinity, deterioration of surface water and groundwater quality, and water pollution), and maintenance of the eco-system.

The water policy of the government aims to provide direction to all agencies working with the water sector, and institutions that relate to the water sector in one form or another, for achievement of specified objectives. These objectives are broadly:

a) To address issues related to the harnessing and development of all forms of surface water and ground water and management of these resources in an efficient and equitable manner
b) To ensure the availability of water to all elements of the society including the poor and the underprivileged, and to take into account the particular needs of women and children
c) To accelerate the development of sustainable public and private water delivery systems with appropriate legal and financial measures and incentives, including delineation of water rights and water pricing
d) To bring institutional changes that will help decentralize the management of water resources and enhance the role of women in water management
e) To develop a legal and regulatory environment that will help the process of decentralization, sound environmental management, and improve the investment climate for the private sector in water development and management
f) To develop a state of knowledge and capability that will enable the country to design future water resources management plans by itself with economic efficiency, gender equity, social justice and environmental awareness to facilitate achievement of the water management objectives through broad public participation

The policies set in the policy are considered essential for addressing the objectives of improved water resources management and protection of the environment. It emphasized that every public agency, every community, village and each individual has an important role to play in ensuring that the water and associated natural resources of Bangladesh are used judiciously so that the future generations can be assured of at least the same, if not better, availability and quality of those resources. It has 17 sections dealing with policy directives for different issues. The main features of different aspects discussed in the policy are mentioned below:

1. **River Basin Management:** This section mainly provides directives regarding working with co-riparian countries. Basin planning provides the most rational basis of development of water resources under the influence of one or more major

rivers. It may take considerable effort and time for Bangladesh to work out joint plans for different river basins with other co-riparian countries. As a long-term measure, therefore, it is the policy of the government to undertake essential steps for realizing basin-wide planning for development of the resources of the rivers entering its borders.

2. **Planning and Management of Water Resources:** The Government recognizes that the process of planning and managing water resources requires a comprehensive and integrated analysis of relevant hydrological, topographical, social, political, economic, environmental and institutional factors across all related water-using sectors. The Water Resources Planning Organization (WARPO) will delineate the hydrological regions of the country for planning the development of their water resources.
3. **Water Rights and Allocation:** The ownership of water does not vest in an individual but in the state. The Government reserves the right to allocate water to ensure equitable distribution, efficient development and use, and to address poverty. The Government can redirect its use during periods of droughts, floods, cyclones, and other natural and man-made disasters, such as contamination of groundwater aquifers that threaten public health and the ecological integrity. Allocation rules will be the formal mechanism for deciding who gets water, for what purpose(s), how much, at what time, for how long, and under what circumstances water use may be curtailed.
4. **Public and Private Involvement:** Government investments in water programme will be directed towards creation of public goods or for addressing specific problems of market failure and protecting particular community interests. Policies and programmes of any public agency involving water resources will be coordinated with the policies and programmes of all other public and private bodies to build synergy and avoid conflict. Public water institutions will, to the extent feasible, use private providers of specific water resources services in carrying out their mandates, giving preference to beneficiary groups and organizations. Appropriate public and private institutions will provide information and training to the local community organizations for managing water resources efficiently.

5. **Public Water Investment:** The Government considers that a consistent and uniformly applied analytical framework for project appraisal is essential to equitable, efficient and effective water resources management. Investments in infrastructure may displace people and disturb ecosystems and, as such, broader water resources planning assessments and specific project appraisals must consider these cross-sectoral implications.
6. **Water Supply and Sanitation:** The rural areas of Bangladesh suffer from lack of quality drinking water. Surface water supplies are generally polluted and groundwater, which till now had been the best source of safe drinking water, is contaminated with arsenic in many parts of the country. To address these problems, it is the policy of the Government to facilitate availability of safe and affordable drinking water supplies through various means, including rainwater harvesting and preserve natural depressions and water bodies in major urban areas for recharge of underground aquifers and rainwater management.
7. **Water and Agriculture:** Support of private development of groundwater irrigation for promoting agricultural growth will continue, alongside surface water development where feasible. For this purpose, the policy of the Government is to encourage and promote continued development of minor irrigation, where feasible, without affecting drinking water supplies and improve efficiency of resource utilisation through conjunctive use of all forms of surface water and groundwater for irrigation and urban water supply.
8. **Water and Industry:** Excessive water salinity in the southwest region is a major deterrent to industrial growth. The policy is to establish zoning regulations for location of new industries in consideration of fresh and safe water availability and effluent discharge possibilities. Standards of effluent disposal into common watercourses will be set by WARPO in consultation with DOE.
9. **Water and Fisheries and Wildlife:** Fisheries and wildlife are integral aspects of economic development in Bangladesh and strongly linked to advancement of target groups, poverty alleviation, nutrition, and employment generation. Fisheries and wildlife will receive due emphasis in water resource planning in areas where their social impact is high. Measures will be taken to minimize disruption to the natural aquatic environment in streams and water channels.

10. **Water and Navigation:** Inland navigation is of substantial economic importance to Bangladesh because its numerous watercourses provide the cheapest means of transportation. Siltation, however, has disrupted river communications in many water channels. The policies of the Government in this regard are to maintain minimum stream-flows in designated rivers and streams for navigation after diversion of water for drinking and municipal purposes and undertake dredging and other suitable measures, wherever needed. Water development projects should cause minimal disruption to navigation and, where necessary, adequate mitigation measures should be taken.
11. **Water for Hydropower and Recreation:** Bangladesh has limited potential for hydropower due to its flat terrain and the absence of suitable reservoir area. However, it may be possible to build mini hydropower plants at small dam and barrage sites. Use of water for recreational purposes is useful for developing tourism facilities. The policy of the Government is that Mini-hydropower development schemes may be undertaken provided they are economically viable and environmentally safe. Also recreational activities at or around water bodies will be allowed provided it is not damaging to the environment.
12. **Water for the Environment:** Protection and preservation of the natural environment is essential for sustainable development. Given that most of the country's environmental resources are linked to water resources, it is vital that the continued development and management of the nation's water resources should include the protection, restoration, and preservation of the environment and its bio-diversity including wetlands, mangrove and other national forests, endangered species, and the water quality. Henceforth, all agencies and departments entrusted with water resource management responsibilities (regulation, planning, construction, operation, and maintenance) will have to enhance environmental amenities and ensure that environmental resources are protected and restored in executing their tasks. Environmental needs and objectives will be treated equally with the resources management needs.
13. **Water for Preservation of Haors, Baors, and Beels:** Water bodies like haors, baors, and beels are precious assets of Bangladesh with unique regional characteristics. These water bodies account for a large share of the natural capture fisheries and provide a habitat for a wide variety of aquatic vegetation and birds. They also provide sanctuary to migratory birds during winter. The haors and the

beels usually connect to some adjoining river through khals. The Government believes that in order to assist the natural processes of groundwater recharge, maintenance of aquatic life and ecological balance, disposal of wastes through the dynamic river system, and for turning the huge water bodies into recreational areas, their planned development is essential. The policy of the Government is that:

a) Natural water bodies such as beels, haors, and baors will be preserved for maintaining the aquatic environment and facilitating drainage.
b) Only those water related projects will be taken up for execution that will not interfere with the aquatic characteristics of those water bodies.
c) Haors that naturally dry up during the winter will be developed for dry season agriculture.
d) Take up integrated projects in those water bodies for increasing fish production.
e) Natural water bodies will be developed, where possible, for recreational use in support of tourism.

The policy has directives regarding economic and financial management, research and information management and stakeholders' participation. The NWPO, 1999 also provides the institutional policy and legislative framework for the implementation of the policy directives. The National Water Policy will be reviewed periodically and revised as necessary.

4.8 Environmental Policy, 1992

The Environmental Policy, 1992 was declared by the Government in 1992. It recognized that the Environment Policy is any action, deliberately taken, to manage human activities with a view to prevent, reduce, or mitigate harmful effects on nature and natural resources, and ensuring that man-made changes to the environment do not have harmful effects on humans. It is useful to consider that environmental policy comprises two major terms: environment and policy. Environment refers to the physical ecosystems, but can also take into consideration the social dimension and an economic dimension. Policy can be defined as a "course of action or principle adopted or proposed by a government, party, business or individual". So, environmental policy refers to a set of guidelines that define action taken by human beings to mitigate the harmful effects of changes to the environment.

The policy observed that over the years, Bangladesh has undergone a process of environmental degradation, which is cause for great concern. Natural calamities like floods, cyclones, tidal surges and tornadoes have resulted in severe socio economic and environmental damage. The major root of man-made problems is lack of understanding of ecological principles, poverty and lack of adequate alternate resources (MoEF, 1992). The single most critical factor that will increasingly hamper development in Bangladesh, if not addressed properly, is the size and rate of growth of an already overwhelmingly large population.

In pursuance of the Stockholm Mandate (1972), the government of Bangladesh, like all other developing and developed countries, actively participated in the evolutionary process of protecting global environment. As a result, the first Water Pollution Control Ordinance was promulgated in 1973 followed by the promulgation of the Environment Pollution Control Ordinance in 1977. In 1985 Department of Pollution Control Ordinance (DPC) was established. Subsequently DPC was renamed and structured as Department of Environment (DOE). The idea of environmental protection through national efforts was first recognized and declared with the adoption of the Environmental Policy 1992. The Government of Bangladesh has also adopted a number of supplementary policies where environment and development issues have been addressed. Important policy documents in this respect are the Forest Policy (1994), the Fisheries Policy (1998), the Water Policy (1999), the New Agriculture Extension Policy (1995), The Energy Policy (1995).

The Environmental policy covered all geographical regions and identified 15 development sectors and they are:

1. Agriculture,
2. Industry,
3. Health & Sanitation,
4. Energy and Fuel,
5. Water Development,
6. Flood Control and Irrigation,
7. Land, Forest, Wildlife and Bio-diversity,
8. Fisheries and Livestock,
9. Food, Coastal and Marine Environment,

10. Transport and Communication,
11. Housing and Urbanization,
12. Population, Education and Public Awareness,
13. Science, Technology and Research,
14. Legal Framework and
15. Institutional Arrangements.

The policy mentioned the suitability of environmentally sound development on proper changes in production management and relations of production of agriculture sector for guaranteeing improvement of environment and sustainable use of its resources. Moreover, the policy necessitated firmly to conduct Environmental Impact Assessment (EIA) on industries of public and private sectors and also encompassed the necessity of integrated environmental concerns that shaped into the National Health Policy. The policy also recommends to ensure environmentally sustainable steps in the local, zonal and national levels of Bangladesh on flood control and its related matters such as construction of embankments, dredging of rivers, digging of canals etc. and to make certain alleviated measures of adverse environmental impact on flood control projects and water resources development projects. The policy subsequently stated the formulation and application of national land use policy to ensure sound and balance environment and prevention of land erosion, preservation and increase in soil fertility, conservation of environmentally sound management of new accreted land, compatible land use system with various ecosystems, prevention of salinity and alkalinity on land.

The objectives of Environment Policy are to:

1. Maintain ecological balance and overall development through protection and improvement of the environment;
2. Protect the country against natural disasters;
3. Identify and regulate activities which pollute and degrade the environment;
4. Ensure environmentally sound development in all sectors;
5. Ensure sustainable, long term and environmentally sound use of all national resources;
6. Actively remain associated with all international environmental initiatives to the maximum possible extent.

The majority of environmental laws in Bangladesh were passed under substantially different population and development conditions. For example, the Factories Act of 1965 and some other health protection laws were designed before industrial pollution and hazardous substances became serious concerns. The Environment Policy of 1992 of Bangladesh has recognized the need for a better and comprehensive approach to address environmental issues. Very few of the elements of the Environment Policy, however, are yet to be translated into laws. The only legislation which specifically deals with environment issues is the Bangladesh Environment Conservation Act (ECA) 1995. The Environmental Conservation Rules, 1997, were promulgated for fulfillment of the objectives of the ECA, 1995. Regarding management of toxic and hazardous substances, the Rules have broadly defined guidelines for disposal of waste from different categories of industries.

Bangladesh has been able to create an enabling policy regime for better management of its environment and natural resources. The policies have adopted in principle the concept of sustainable development and it has also recognized the importance of economic development that goes hand in hand with the control of environmental pollution and maintaining ecological balance. The formulated Environment Policy although fairly rich in content is not supported by necessary actions of implementation. The implementation of the Environmental policy and the Environmental Protection Act have been bogged down due to some institutional and functional limitations.

Formal responsibilities of overall environment sector are vested with the Ministry of Environment and Forest (MoEF). However, many other institutions, directly and indirectly, are involved in managing or shaping the environment sector. These embrace public sector, private sector and civil society institutions. Major institutions involved in the development and implementation of plans and policies are the Planning Commission, Department of Forest, Department of Environment, Ministry of Agriculture, Ministry of Fisheries and Livestock, Ministry of Water Resources, Ministry of Energy, Ministry of Health and Family Welfare, Ministry of Education, Ministry of Housing and Public Works etc. At the higher level, National Environment Council (NEC) headed by the Prime Minister and Executive Committee of National Environment Council (ECNEC) headed by the Minister for Ministry of Environment and Forest provide guidance to the sectoral Ministries/Agencies on matters of national environmental management. At the Divisional level, Divisional Environment

Committee chaired by the Commissioner with representation from all other government are supposed to deal with environmental issues at the local level.

4.9 The Draft Wetland Policy of Bangladesh

Govt. of Bangladesh does not have any exclusive national Wetland Policy. IUCN, Bangladesh prepared a (draft) Wetland Policy. Bangladesh possesses enormous area of wetlands including rivers and streams, freshwater lakes and marshes, haors, baors, beels, water storage reservoirs, fish ponds, flooded cultivated fields and estuarine systems with extensive mangrove swamps. Twelve million people are directly dependent on these wetlands and possibly another twenty million are indirectly dependent on them. Up until four thousand years ago, Bangladesh was probably the largest single wetlands area in the world. But the rise in population and subsequent development activities have been causing the decline in the quality of wetlands and its natural resources. This steep decline of wetlands has alerted the government to the need for a policy statement on Wetlands in order to conserve and utilize the massive amount of natural resources.

Draft Wetlands Policy gives a definition of wetlands in the context of Bangladesh and is quoted below.

> "*Wetlands are defined as the areas of land surface which are flooded seasonally or remain under water permanently, either naturally or artificially, they may perform some known functions such as water reservoir, ground water recharge, capture fishery area, aquaculture fish sanctuary, wildlife sanctuary, navigation channel, cultivated area etc."*

The definition is somehow in accordance with the definition of wetland of the Ramsar Convention. For conservation purposes, the draft policy proposes the following classes of wetland to be defined and delineated:

> **Class 1:** Estuarine tidal plains could be designated. This would include all mangrove areas and therefore there is no need to give a special designation to the Sundarbans area.
>
> **Class 2:** All lacustrine wetlands (beels, haors, baors).
>
> **Class 3:** Fluvial (rivers, khals, chharas) wetlands.
>
> **Class 4:** Seasonally inundated agricultural lands

In wet tropical regions with monsoonal rainfall pattern like Bangladesh, wetlands have very important functions. Extreme effects of seasonal changes are mitigated. Wetlands also provide both ecological and socio-economic functions of great importance. The functions of wetlands are:

- Ecological Functions
- Maintenance of the water table
- Retention of rain water for dry season
- Reduction of the effects of floods
- Sediment traps
- Wildlife habitats
- Centers of biological diversity
- Biodegradation of toxins
- Fisheries
- Plant products
- Cattle grazing

Due to increase of population, infrastructure development, urbanization and other economic activities including agriculture and fisheries, large areas of wetlands have been poldered and turned into flood-control and drainage projects. Government has been aware of the mentioned problems and has tried to mitigate their effects. The major planning documents in the past few years have contained references to the situation of wetlands.

The report reviewed the following policies and plans. They are:

1. The National Water Policy, 1999
2. The Environmental Policy, 1992
3. The National Conservation Strategy, 1991
4. The National Environment Management Action Plan (NEMAP), 1995

The major identified policy issues are:

1. Database
2. Resource assessment
3. Global conservation value
4. Biodiversity value

5. Environmental considerations
6. Fisheries augmentation
7. Agricultural use
8. Effects of Infrastructure Development
9. Siltation
10. Tourism
11. Evaluation & Implementation of Projects
12. Research
13. Human Resources Development
14. Institutional Issues
15. Legal Issues
16. Regional and International Cooperation

The report proposed that the Wetlands Policy will be based on the following key Principles:

“

1. *Wetland resources form a very important part of the environment in Bangladesh and therefore their conservation must be ensured.*
2. *Wetland conservation will not exclude development of resources, provided that this development is ecologically sustainable and economically beneficial to the people of the locality.*
3. *Wetland conservation and development must involve the local communities and therefore people's participation must be ensured.”*

4.10 National Water Management Plan, 2004

The National Water Management Plan was prepared by Water Resources Planning Organization (WARPO) and published on 2001. The Government commenced preparation of the National Water Management Plan, with the intention of operationalizing the directives given by the National Water Policy. The National Water Management Plan has been prepared to respond to the challenges and paradigms, with **three central objectives** consistent with Policy aims and national goals. These objectives are:

- Rational management and wise-use of Bangladesh’s water resources
- People’s quality of life improved by the equitable, safe and reliable access to water for production, health and hygiene

- Clean water in sufficient and timely quantities for multi-purpose use and preservation of the aquatic and water dependent eco-systems

The **Development Strategy**, agreed in the course of Plan preparation, requires that equal importance be given to each of the national 6 national goals. The Plan is structured in a manner that the objectives of **84 different programmes** planned for the next 25 years contribute individually and collectively to attainment of both the overall objectives as well as to intermediate sub-sectoral goals; The short-term (2000-05) is considered a firm plan, the medium-term (2006-10) an indicative plan, and the long-term (2011-25) a perspective plan. The programmes are grouped into eight sub-sectoral clusters and spatially distributed across eight planning regions of the country. Information on each, together with a wide range of planning data, is held on the National Water Resources Database, accessible through a Management Information System. The three main categories of programmes are Cross-Cutting Programmes, National-level Programmes and Regional Programmes.

Cross-Cutting Programmes are applicable to all activities in each sub-sector and region. They embrace the necessary actions for institutional development and creation of an enabling environment conducive to efficient and equitable management of the sector as a whole. Other than the introduction of new regulatory bodies for the water supply and sanitation services sector, existing organizations will be strengthened to fulfil their obligations within a rationalized and decentralized institutional framework. Emphasis is given to expanding community participation and the role of the private sector. Action will be taken to fill knowledge gaps and improve information management. A National Water Code will provide the basis to a comprehensive legal and regulatory framework.

National-level Programmes will be taken up to address major strategic issues that merit special attention. Building on the research programmes included above, a long-term strategy for securing water supplies for Bangladesh will be developed. First priority will be given to making optimal use of the Ganges waters. Second priority will be given for the utilization of the Brahmaputra river water and integrated development of the Meghna River. Reviews will be made of options for dealing with main and regional river erosion and of hydropower based on current experience, and actions will be taken accordingly. A long-term pollution control plan will be drawn up and, within this, immediate steps taken to clean-up existing pollution.

Restoration of flood-plain and river fisheries and improved management of environmentally critical areas will be taken up as soon as possible.

Regional Programmes fall into the sub-categories of generic and region-specific. Generic programmes are those that are applicable to all or most regions, for which there are three main themes. Firstly, an integrated approach to river system development will be introduced with management plans for each reflecting the full spectrum of user needs, environmental requirements and water conservation. Development of main, regional, sub-regional and community-managed systems will be coordinated. Secondly, management of existing public flood control and drainage and irrigation schemes will be enhanced and devolved in line with Policy directives, with special attention given to environmental issues. In addition, continued support will be given to minor irrigation, and where appropriate and feasible, this will be supplemented by public investment in river augmentation and irrigation schemes. The third major theme addresses the back-log in rural and urban water supply and sanitation, overcoming the arsenic problems and meeting future evolving demands for rural and urban water services, including urban flood protection and storm drainage. The second sub-category of Regional Programmes is made up of those programmes that are specific to one or two regions only. They will be taken up to meet particular local needs, such as cyclone protection, flood-proofing in charland, Haor, rural areas, improving the coastal embankment system, relieving drainage congestion, erosion control, and specific environmental management measures in the Sundarbans and the Tanguar Haor Basin.

The programmes have been scheduled in a manner to smooth investment flows. Priority is given to the institutional development, enabling environment, water supply and sanitation, rationalization of FCD&I management and key elements of the natural environment programmes. The former two are fundamental requirements for efficient and effective of all other programmes. Rationalization of FCD&I is a central tenet of Policy and the latter two are necessary to start immediately to avert crises in public health and irreversible environmental degradation.

Implementation of the Plan will bring **multi-dimensional benefits** to Bangladesh consistent with national goals. The cross-cutting programmes will bring about decentralized management, responsive to user demands, with greater accountability and transparency. The burden on Government funding will have been reduced through increased cost recovery and

mobilization of alternative funds. Management of the water resource system will be enhanced through comprehensive and coordinated development of the river systems at all levels. Water-related constraints to agriculture and fisheries will have been minimized and safeguards introduced to protect the quality of water for human and environmental purposes. Access to safe and reliable water supply and sanitation services will have been greatly extended to all segments of society. People will be better able to cope with natural disasters.

The NWMP programmes are to be implemented by line agencies and others as designated. Each organization is responsible for planning and implementing its own activities and projects within the NWMP framework. Projects may be designed to implement only part of a programme or aspects of one or more programmes. This is a matter for the agency in question to determine on the basis of practical experience, current knowledge and capacity. Sequential and technical linkages between programmes have been identified. All projects will adhere to normal Government administrative procedures and will conform to all relevant rules and guidelines issued by Government. Responsibility for overall coordination of Plan's implementation lies with the National Water Resources Council, who will issue directives as required through its Executive Committee.

As secretariat to the NWRC, **WARPO will monitor progress and impacts** and draw to Council's attention issues that require their particular consideration. At a working level, coordination of project activities will conform with directives as issued from time to time by Government. **Issues of prioritization** will be considered by Government in the event that funding is at any time insufficient to meet the requirements for short-term firm programme requirements. Decisions in this regard will be guided by the prevailing state of implementation of the Plan. However, it will remain the prerogative of Government through its democratic processes to assign sub-sectoral budgets each year.

Risks have been identified at both Programme and Plan levels. Those considered central to the success of the Plan include:

- The willingness of both Government and its agencies to put into the operation the new paradigms (decentralization, cost sharing and recovery, community and private sector participation, non-traditional financing modalities, regulation, new rights, obligations and accountability). Changing the culture of institutions and evolving new ones, which takes time, requires an immediate start backed by strong political stewardship.

- Sustained economic growth is essential if the necessary investments, particularly those in urban and rural services, are to be realized. Government's ability to fund its share of the capital and recurrent costs is dependent upon this growth and the extent to which, through fiscal and regulatory reform, it creates an environment conducive to alternative funding.

Important assumptions are that necessary parallel actions will take place in support of Plan implementation. These include introduction of wider civil service reforms, establishment of all tiers of Local Government, preparation of land-use and physical planning strategies notably with regard to managing rapid urbanization, and promulgation of an integrated transport policy.

Among the 84 programmes, the following programmes deal with the development of wetlands.

Table 4.5: List of Programmes in NWMP Dealing With Wetlands

Program No	Program Title
Cluster 3: Main Rivers	
MR 001	Main River Studies and Research Programmes
MR 002	Main River Abstraction Projects
MR 003	Ganges Barrage and Ancillary Works
MR 004	Meghna Barrage and Ancillary Works
MR 005	Brahmaputra Barrage and Ancillary Works
MR 006	Regional River Management and Improvement
MR 007	Ganges Dependent Area Regional Surface Water Distribution Networks
MR 008	North East and South East Regional Surface Water Distribution Networks
MR 009	North Central and North West Regional Surface Water Distribution Networks
MR 010	Main Rivers Erosion Control at Selected Locations
MR 011	River Dredging for Navigation
MR 012	Hydropower Development and Upgrading

Program No	Program Title
Cluster 4: Towns and Rural Areas	
TR 003	Large and Small Town Water Supply and Distribution System
TR 004	Rural Water Supply and Distribution System
TR 005	Large and Small Town Sanitation and Sewerage System
TR 007	Large and Small Town Flood Protection
Cluster 5: Major Cities	
MC 002	Dhaka Bulk Water Supply and Distribution Systems
MC 003	Chittagong Bulk Water Supply and Distribution Systems
MC 004	Khulna Bulk Water Supply and Distribution Systems
MC 005	Rajshahi Bulk Water Supply and Distribution Systems
MC 006	Dhaka Sanitation and Sewerage System
MC 007	Chittagong Sanitation and Sewerage System
MC 008	Khulna Sanitation and Sewerage System
MC 009	Rajshahi Sanitation and Sewerage System
MC 010	Dhaka Flood Protection
MC 012	Chittagong Flood Protection
MC 014	Khulna Flood Protection
MC 016	Rajshahi Flood Protection
Cluster 6: Disaster Management	
DM 003	Flood Proofing in the Charlands and Haor Basin
Cluster 7: Agriculture and Water Management	
AW 002	Improved Performance of Existing Public Surface Water Irrigation Schemes
AW 003	New Public Surface Water Irrigation Schemes
AW 007	Rationalization of Existing FCD Infrastructure
AW 008	Land Reclamation, Coastal Protection and Afforestation
Cluster 8: Environment and Aquatic Resources	
EA 001	National Pollution Control Plan

Program No	Program Title
EA 002	National Clean-up of Existing Industrial Pollution
EA 007	Improved Water Management in The Haor Basins of the North East Region
EA 008	Environmentally Critical Areas and Integrated Wetland Management
EA 009	Improved Water Management and Salinity Control in the Sundarbans

4.11 Summary Report Based on Studies Carried Under the Flood Action Plan, 1994

The draft final report of the Flood Action Plan based on 11 main studies and 15 supporting studies was prepared jointly by the GOB personnel and the Panel of Experts of the Flood Plan Coordination Organization (FPCO). The draft of programme of FAP was presented at a meeting of the development partners in London in December, 1989. The Executive Summary of the draft report was released on November 1994.

This report mainly discusses the main focal points of each of the 26 FAP reports published previously. FAP was launched for developing a flood mitigation plan which would, in the long run, provide a comprehensive and durable solution to the recurrent flood problem so as to create an environment for sustained economic growth and social uplift. The main objectives of the plan were to:

- Safeguard life and livelihoods
- Minimize potential flood damage
- Improve agro-ecological conditions for enhanced crop production
- Meet the needs of fisheries, navigation, communications and public health
- Promote commerce and industry
- Create flood-free land for a better living environment

Eleven guiding principles were formulated for flood mitigation strategy (UNDP-GOB 1989) which were abridged for adoption under the FAP (WB 1989). At the time of formulation of the guiding principles, it was established that total elimination of flooding is neither practicable nor desirable from agro-ecological viewpoints. Controlled flooding was, therefore, adopted as the central theme for planning FAP projects.

FAP regional studies recognize the wide differences in the land and water regimes among the regions. Bangladesh was primarily divided into six regions and each was the subject of an independent study. The studies have drawn on numerous technical resources and planning tools developed by FAP. These include up-to-date maps, satellite imagery, geographic information system, global positioning system, hydrodynamic modelling and more accurate hydrological data. The primary regions in Bangladesh are:

1. Northwest region:
   Bounded by the Ganges to the south and by the Brahmaputra/Jamuna to the east
2. Northcentral region:
   Bounded by the Brahmaputra/Jamuna to the west and the Old Brahmaputra to the east
3. Southwest region:
   West of the Kumar and south of the Ganges
4. Southcentral region:
   East of Kumar. West of Lower Meghna and south of the Padma
5. Southeast region:
   East and south of the Meghna/Titas and Lower Meghna. The region ends in Noakhali to exclude Chittagong and Chittagong Hill tracts.
6. Northeast region:
   Meghna-Titas to the south southwest.

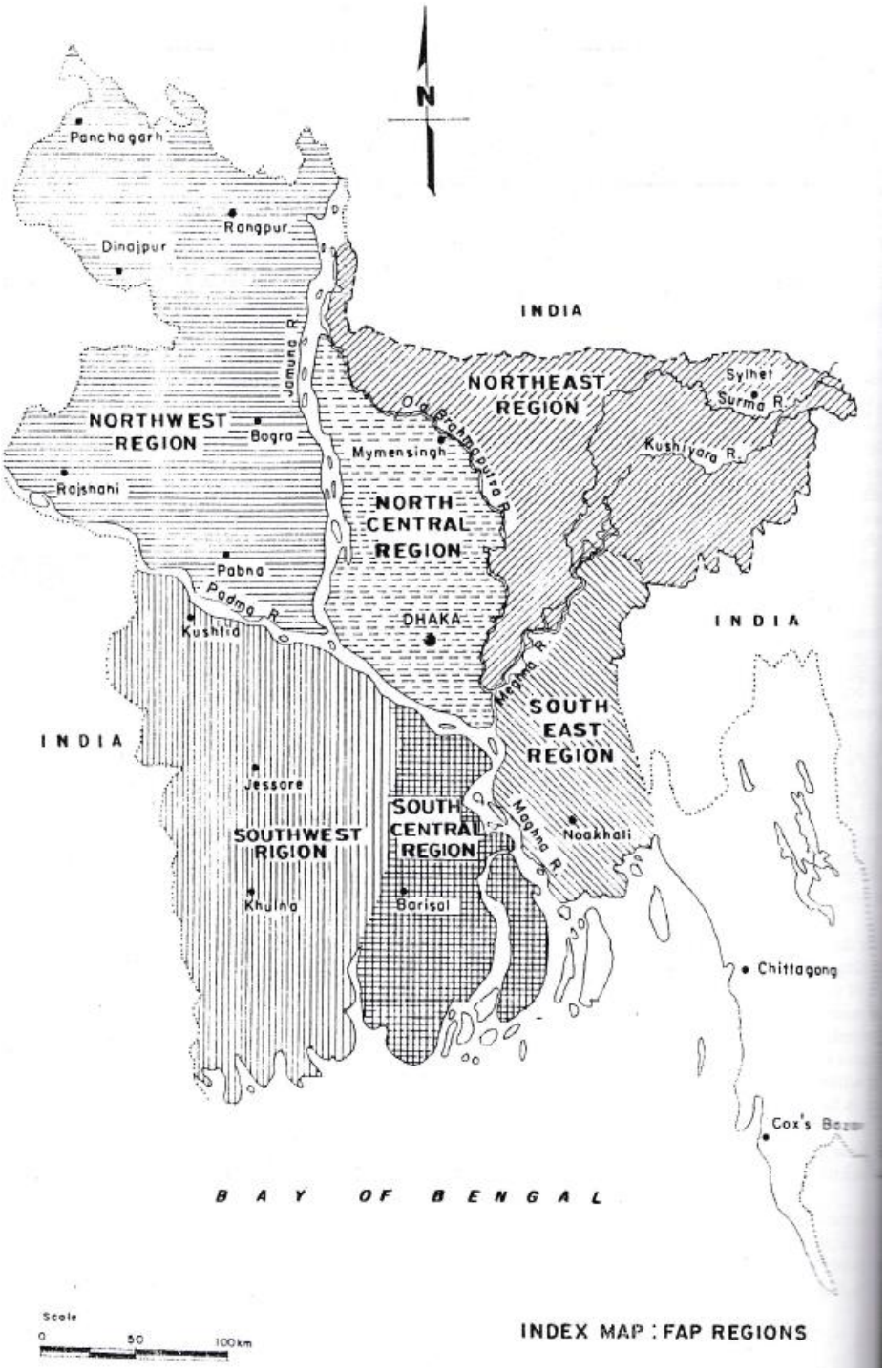


Figure 4.1: Regions of Bangladesh (Source: FPCO, 1994)

The main components of the Flood Action Plans are given in the Box 4.2.

	Title	Donor(s)
FAP-1	Brahmaputra Right Embankment Strengthening	IDA
FAP-2	Northwest Regional Study	UK/Japan
FAP-3	North Central Regional Study	EC/France
FAP-3.1	Jamalpur Priority Project	EC/France
FAP-4	Southwest Area Water Management Study	UNDP/ADB
FAP-5	Southeast Regional Study	UNDP
FAP-6	Northeast Regional Study	Canada
FAP-7	Cyclone Protection Study	EC
FAP-8a	Greater Dhada Protection Project	Japan
FAP-8b	Dhaka Integrated Town Protection Project	ADB/Finland
FAP-9a	Secondary Towns Protection Project	ADB
FAP-9b	Meghna Left Bank Protection Project	IDA
FAP-10	Flood Forecasting and Early Warning Project	UNDP/ADB/Japan
FAP-11	Disaster Preparedness Programme	UNDP
FAP-12	FCD/I Agricultural Review	UK/Japan
FAP-13	Operation and Maintenance Study	UK/Japan
FAP-14	Flood Response Study	USA
FAP-15	Land Acquisition and Resettlement Project	Sweden
FAP-16	Environmental Study	USA
FAP-17	Fisheries Study and Pilot Project	UK
FAP-18	Topographic Mapping	France/Finland/ Switzerland
FAP-19	Geographical Information Systems (GIS)	USA
FAP-20	Compartmentalization Pilot Project	Netherlands/Germany
FAP-21/22	Bank Protection, River Training and Active Flood Plain Management Pilot Project	Germany/France
FAP-23	Floodproofing Pilot Project	USA
FAP-24	River Survey Programme	EC
FAP-25	Flood Modelling Management Project	Denmark/Netherlands/ France/UK
FAP-26	Institutional Development Programme	UNDP/France

Components of the Flood Action Plan and donors
(Source: FPCO, 1992j)

Box 4.2: Main components of the Flood Action Plan

Five regional studies have been completed. Their main outcome is the development of regional water management plans. For the northwest and north-central regions (FAP-2 and FAP-3), the focus was primarily on flood control and drainage while other three regional studies (FAP-4, FAP-5 and FAP-6) covered wider issues of year-round water management. All regions except the north-east (FAP-6) were divided into several planning units (PU) to

help in classifying their characteristics and to allow alternative development strategies to be prepared. Salient features of the five regional plans are briefly discussed below:

North West Region (FAP-2): There are two types of flooding in the region: breaches in the major river embankments and backwater effect of the major rivers during the monsoon. Other problems are bank erosions along the major rivers and drainage outflow problem. The main objective of this study was to create a stable flooding regime which gives local people the ability to plan their lives with some degree of confidence and which allowed them control of the local natural resources.

North Central Region (FAP-3): Flooding and drainage of the region is influenced by the three major rivers forming the boundary. Drainage outflow from the region is impeded when the water levels are high on the boundary rivers. The proposed approach is one of permitting sufficient flooding so as not to adversely impact fisheries and navigation.

South West and South Central Regions (FAP-4): Major issues in this region are acute shortage of water in the dry season, flooding from the Padma and the Lower Meghna, protection of scarce ground water resources, deterioration of the Sundarbans due to change in water regime, salinity intrusion and associated environmental degradation and adverse impact on river morphology.

South East Region (FAP-5): Major development issued are flood control, drainage and irrigation. In the south there are problems of cyclone and salinity intrusion, land intrusion and accretion. The main components of the regional water plan include both structural and non-structural elements. Many of the structural components will require further studies before implementation.

North East Region (FAP-6): Main Issues are round the year water management, flash floods, sedimentation, rapid shifting of river courses, depletion of water bodies etc.

4.12 North West Regional Study (FAP-2), 1992

The North West Regional Study (FAP-2) was prepared by Mott Macdonald International in association with Hydraulics Research LTD. and House of Consultants under assignment to Overseas Development Administration and Nippon-Koel CO. LTD. in association with Nikken Consultants INC. under assignment to Japanese International Cooperation Agency. The North West Regional Study Final Report describes proposals for the Regional Water

Development Plan and the results of the project preparation studies for the Gaibandha improvement project.

The North West region consists of 3.5 million ha and has a population of 25 million people. It shows considerable variation, in relation to such aspects as climate, topography and water resources. The region has a typical monsoon climate. Average rainfall ranges from less than 1500mm to just over 3000mm, with an average of about 1900mm. Over 80% of the annual rainfall occurs during the five monsoon season between May and September, and this rises to an average of 97% for the seven months from April to October.

The hydrology of this area is influenced by the topography and the drainage network, and in particular by the major rivers which bound it. The characteristic topographical feature of the region is its flatness even though it is not as flat as other parts of the country. Elevation varies from less than 10m above sea level in the South East corner to just under 100m in the far North West. Most of the region lies 30m above sea level. In the southern part 1m contours are typically up to 5km apart, and even in the North West of the region average slopes rarely exceed 1 in 1000. As a consequence of the low gradients, the rivers and drainage channels within this region are generally heavily meandered, and capacity for rapidly passing flood peaks is very limited. The region slopes from north towards the south-east, with an altitude range of 90m to less than 10m above sea level. The most basic division is that between the Barind and Alluvial tracts; the latter comprises of three main geomorphological units. Slopes in the Barind tract, which has non-alluvial soils, are generally steeper and flooding is much less widespread than in most part of alluvial zone. Most of the region’s soils are capable of high levels of productivity.

The region is bounded, and effectively defined, by the Jamuna (Brahmaputra) to the east and the Ganges to the south. These two rivers, into which the entire area drains, meet at the south east corner of the region and play a dominant role in constraining its drainage. Before the construction of the confining embankments, the Ganges and Jamuna rivers were major contributors to flooding in the region, and in more recent times they have also been so at times of breaches of the embankments. Three large tributaries of Jamuna, the Teesta, Dharla and Dudhkumar, pass through the north east corner of the region, and the Mohanonda, a tributary of Ganges, passes through the south west corner. All other rivers in the region are connected to the Atrai-Karatoya-Bangali system which drains to the Jamuna through the Hurasagar at the south east corner to the region. The Teesta, Dharla, and Dhdhkumar rivers

originate in the Himalayas and Himalayan Piedmont Plains. The Mohanonda River has a large catchment area in India to the west of Barind Tract, but it also fed by outflows from the north western corner of Bangladesh via the Tangon and Punarbhaba which pass through India before joining the Mohanonda in the south west of the region. The river Atrai rises in the West Bengal to the north of Panchagrah. Its catchment area in India is fairly small, but it is subject to occasional spillage from upper Teesta at times of exceptional flood flows. Together with the Tangon and Atrai drains the north west corner of the region. North of Dinajpur, it bifurcates into the western Punarbhaba branch and the eastern Atrai branch, both of which pass through the Indian Barind enclave and return to Bangladesh further south. Subsequently the Atrai turns south eastward and picks up various tributaries including the Little Jamuna, Nagor and Barnai before joining with the Bangali to become the Hurasagar which is the major outflow channel for the internal drainage of the region to the Jamuna. The Karatoya rises as Jamuneswari, which has only a very small contributing catchment in India. After flowing in generally south or southeast direction, the Jamuneswari becomes the Karatoya and Joins Alai, part of Ghagot system, and a tributary flowing roughly parallel to the east. Further southwards, the Karatoya becomes Bangali; channels bifurcate and rejoin at several places before joining the Atrai to form the Hurasagar.

Within the region, the rivers in the north east corner have relatively steep gradient of 1 in 2000 or more, but in nearly all remainder of the area river courses have very flat gradients of 1 in 5000 or less. The rivers are consequently heavily meandering and have limited capacity of passing flood discharges. The system in exacerbated in the lower areas by tendency of some channels to overflow towards others during flood periods. An additional factor of fundamental importance to the flooding problems in the southern part of the region is the fact that flood levels in the Ganges and the Jamuna are often equal to or higher than internal river levels for long periods during the monsoon. The great bulk of the internal drainage therefore ponds in the lower Atrai/ Hurasagar/ Bangali against the backwater effects of Jamuna. Even in a relatively dry year such as 1992 extensive areas were flooded for long periods. Past attempts to reclaim land in this area by constructing polders has in some cases seriously confined flood drainage courses, with a consequent increase in typical flood levels in other places.

Flooding and drainage problems in the region may be separated into a number of categories depending on their courses and location. The first type of flooding in the region is due to breaches in the embankments of major rivers – primarily the Jamuna, but also Teesta. The

second type of flooding is due to outfall constraints, primarily from Hurasagar to Jamuna. This comprises flooding in the lower Atrai and Karatoya-Bangali systems, and predominantly caused by high stages in the Jamuna causing backing up of levels in the river system. A third type of flooding that is caused by storm sun off in the catchments of the region. These problems are often much localized in nature. The severity of flood problems can be critically influenced by the timing of flood peaks on the two main rivers.

Planning for the region has based on number of broad principles. The main objective has been to create a stable flooding regime which gives local people the ability to plan their lives and allowing them to control of the local natural resources. A second aim has been to create a sustainable pattern of development. Within the broad objectives a number of other principles have been applied. The most significant feature of flood protection measure is the impact that they have on adjacent or downstream areas. Generally, flood control in one area leads to increased water depths or discharges and consequent disbenefits elsewhere. So this suggests that small-scale schemes often perform better than large ones. So this FAP made efforts to introduce the concepts of compartmentalization, in which protected areas are sub-divided into smaller units provided with structures and facilities which will give local people control of flood and water resources. There are also considerable number of non-structural measures which can also be applied to reduce or mitigate flooding problems. For flood control and drainage, the whole region is divided into 15 units and development schemes are suggested for each units separately. Also possible nonstructural measures are suggested for flood mitigation.

4.13 North Central Regional Study (FAP 3), 1992

FAP 3, North Central Regional Study was prepared by Commission of the European Communities and Caisse Centrale de Cooperation Economique, Government of France is association with BCEOM, Compagine Nationale du Rhône, Euroconsult, Mott MacDonald International, SATEC Development. The North Central Regional Study final report proposes a series of development projects for both the mitigation of flood and agricultural development. The study area is comprised of a major part of eastern Jamuna flood plain.

The North Central Regional hydrological system is dominated by three major rivers. The Bangshi river in the East, the Jhenai-Futikjani system in the central part and Pungli river in the South. The Bangshi off-take from Old Brahmaputra was closed in early 70’s. Now this river is fed by direct run-off from the western slope of Madhupur tract and local rainfall. The

Jhenai river drains a large part of Jamalpur area before entering the eastern Jamuna flood plain through the Baushi Railway Bridge. In the eastern Jamuna floodplain area, the Jhenai river bifurcates, the major channel westward and the other one, flowing southward. This latest channel is called Baruna river or Jhenai river and carries a little part of the total discharge. The main channel, then divides once more into two channels, the Jhenai West and Atrai. The Jhenai-West, is now closed by Jagannathganj-Bhuapur BWDB embankment, the Atrai river carrying the major discharge, also collects water from the Boalbari Khal at Belua Bazar. This Khal results from Jamuna water in-flowing at Sakaria 2 vent sluice regulator. These channels finally join the Futikjani river, near Bhuapur. The Futikjani river flows into the area through the Bhuapur 10 gate-sluice regulator, then collects water from the Jhenai system at 23 points upstream of Nolsafa. Downstream of Nolsafa, it then divides into two channels, Futikjani and Nangali-North. The Nangli river has been completely captured Futikjani and Bangshi. It initially forms a diversion channel from the Futikjani, then just downstream of Kauljani it collects a small part of Bangshi discharge joining the Pungli river near Basai. The Pungli forms the Northern intake channel of Dhaleswari system. It joins the Bangshi river near Mirzapur.

This North Central Regional Study report primarily collected hydrologic data of the region. The analysis of the collected data illustrated the problems that can occur regarding reliability and accuracy. Important discrepancies in the topographical survey was observed using the BWDB datum and SoB-Finmap. Also the many discharge measurements were of low use because of the unreliability of the instruments used by BWDB. Mean Water Level and Discharge were presented in annexes for ten observed stations.

4.14 Southwest Regional Study (FAP 4), 1993

FAP 4, the Southwest Regional Study was prepared by the Sir William Hallcrow & Partners Ltd., in association with Danish Hydraulic Institute, Engineer & Planning Consultants Ltd. and Sthapati Sangshad Limited. The report was published on August 1993. The report forms a component of the Bangladesh Flood Action Plan (FAP) formulated in 1989 as the first stage of a long-term programme to implement a countrywide flood control strategy. The project was funded by the United Nations Development programme (UNDP) and the Asian Development Bank (ADB) with ADB acting as executing agency commenced on 20 October 1991 with a 19-month study period.

The final report is produced in 13 volumes. Volume 1 is the main report. The full list of the volumes is:

1. Vol 1: Main Report
2. Vol 2: Hydraulic Studies
3. Vol 3: Morphological Studies
4. Vol 4: Coastal Studies
5. Vol 5: Hydrology, Hydrogeology and RAOM
6. Vol 6: Land Resources, Agriculture and Fisheries
7. Vol7: Forestry and Navigation
8. Vol 8: Engineering
9. Vol 9: Impact Studies
10. Vol 10: Economics
11. Vol 11: Regional Data
12. Vol 12: Pre-feasibility study of the Gorai Augmentation Project
13. Vol 13: Pre-feasibility studies of selected Projects

The Southwest Area (SWA) includes the Southwest and Southcentral regions, comes under the jurisdiction of the greater districts of Kushtia, Jessore, Faridpur, Khulna, Barisal and Patuakhali which includes 16 Zilas of Khulna Administrative Division, 5 Zilas of the Dhaka Administrative Division and Haimchar Thana in the Chandpur Zila of Chittagong Administrative District. The SWA has been divided into 27 Planning Units (PU), 14 in SWR and 13 in SCR.

The study area has a typical monsoon climate with a warm and dry season from March to May followed by a rainy season from June to October and a cool period from November to February. The mean annual rainfall is 2000 mm.

The Southwest area is demarcated by the course of the major rivers bounding the area, the Ganges, Padma and Lower Meghna together with the Bay of Bengal to the south. More than half of the rivers in the region are tidally influenced. The major rivers of the area are Gorai, Madhumati, Lower Madhumati, Arial Khan, Swarupkathi, Buriswar, Bishkhali, Tentulia etc.

Surface water resources fall into two categories. The first is that which is associated with flows across the Regional boundaries and the second is runoff which is a consequence of rainfall falling within the regions. The quality of surface water outside of the areas of saline intrusion is understood to be generally good. But the critical issue is the extent of saline

intrusion. Water is used for variety of means including irrigation, potable and industrial water supply, navigation, agriculture etc. The project area is underlain by alluvial sediments of the Bengal Basin, laid down by the Ganges-Brahmaputra-Meghna river system. Within this, an aquifer system can be identified which closely relates to the lithological sequence. Most groundwater movement within this system is vertical.

The FAP 4 provides focus on the central objectives for water management development planning. According to this report, the future development of the Southwest and South Central regions' water resources should be with clear objectives in mind. The objectives are:

- Conformity with Govt. policy and FAP Guidelines
- Satisfaction of Socio-economic needs of the people of the Regions
- Sustainable development, recognizing and harmonizing with the natural and physical changes occurring within the regions
- Ensuring that best use of resources is made in support of the goals above

The main water management development options that have been identified are:

- Groundwater Development
- Flood Control, Drainage and Irrigation
- Surface Water Augmentation via the Gorai
- Ganges Barrage
- Surface Water Augmentation via the Arial Khan - Madaripur Beel Route
- Ganges Padma Right Embankment
- Lower Meghna Right Bank
- Coastal Polder Rehabilitation

4.15 South East Regional Study (FAP 5), 1993

The South East regional study (FAP 5) was funded by the United Nations Development Programme (UNDP). The project started in 1990 and completed in 1993. The report was published on August 1994. The southeast region covers an area of 3550 sq. km with a population 12.8 million. It is bounded by the Feni to the southeast, the Meghna and Lower Meghna to the west, the Titas to the North and Bay of Bangal to the south. Almost the entire region is low-lying and flat. Elevations are about 3-4 m along the Meghna and 5-12 m along the Indian Border. The slight slopes which exists are generally from east to west and from north to south. Natural ground levels adjacent to the Meghna vary hardly at all over a total

length of more than 150 km. The northern part of the region is dissected by a number of rivers which carry waters from the hills above the Indian border to the Meghna. These rivers flow in well-defined channels but are flashy and carry large quantities of sediments.

The region receives a heavy rainfall in the monsoon from May to September. The coastal parts of the region receive the heaviest rainfall (3800 to 4000 mm) and in the north the annual rainfall is around 2000 mm. The coastal area is subject to the effects of cyclones mainly in October/November and April/May. Rainfall from October through April is much lighter and less predictable.

Major development issues are flood control, drainage and irrigation. In the south there are problems of cyclone and salinity intrusion, land erosion and accretion. The main components of the regional water plan include both structural and non-structural elements. Many of the structural components will require further studies before implementation. The plan also includes a number of projects which are already under implementation. Non-structural measures include mitigation of adverse effect on fishery, flood proofing, environmental protection and monitoring and public participation at all stages of development.

Flooding in the region can result from three main sources: direct rainfall, overbank flooding from the Meghna and spillage from the internal rivers (mainly flash floods). The latter often flood due to pre-monsoon storms. In the north all three causes are present and high levels in the Meghna can cause prolonged deep flooding. In the middle part, the areas are better protected by embankments. However, the area is prone to flash flooding and suffers from heavy rainfall. In the southern part, the areas are subjected to tidal effects, salinity intrusion and cyclone surges. Natural drainage is restricted by polder embankments and continuing coastal accretion.

The first element of the regional development strategy is to improve water management through flood protection and drainage. A second element is to expand irrigation, where possible, by improving the natural water distribution system and protecting land from salinity intrusion.

The Southeast region, lying entirely to the east of all the main river systems of Bangladesh is divided into 13 Planning Units (PU) based on the regional sub-divisions. In addition, the following three factors are taken into account:

- For a water plan, it is logical that the unit boundaries are water related than being based on administrative districts; such boundaries include rivers and catchment dividers.
- Boundaries are also created where embankments of existing roads and railways form logical divides.
- Existing project boundaries are used where appropriate.

The Planning Units (PU) are grouped into three sub-regions as follows:

- Units 13 to 10 or the Titas Gumti Sub-Region
- Units 9 to 3 or the Dhonagoda-Dakatia Sub-Region
- Units 1 and 2 or the newly accreted marine charland

The plan included in the report includes a number of projects which have been developed so as to minimize fisheries losses and at the same time offer opportunities for increased development of culture fisheries. The main components of the regional development project include both structural and non-structural elements. The plan also includes a number of projects which are already under implementation.

4.16 North East Regional Water Management Project (FAP 6), 1994

"The Flood Action Plan for Bangladesh is the first stage in the development of long-term water management plan. It is comprised of a phased programme of initiatives to control flooding, supported by special studies, surveys and pilot projects." (FAP 6, 1994)

Physical Setting of North East Region:

The Northeast region has area of 24,200 km^2 which is 17.5% of the total area of Bangladesh. The region experiences some of the most severe hydrological conditions in the country. The region receives very large amount of water from the catchments on the slope of the Shillong Plateau across the border in India to the north and the Tripura Hills in India to the southeast. Run-off from these catchments discharge into a large central depression in the region, the Haor area or Central basin which remain flooded for more than six months each year.

Principal rivers of the region include the Surma and Kushiyara which drain the eastern side of the region, the Kangsha which drains the western side, and the Kalni and Baulai which drain the Central Basin. These rivers all discharge into the Meghna a short distance upstream of Bhairab Bazar. The Old Brahmaputra River and its distributary channel, the Lakhya from the

western boundary of the region discharge into the Meghna downstream of Bhairab Bazar. The downstream reach of the Old Brahmaputra below the Lakhya offtake is virtually abandoned and only carries flow during the flood season. The main source of flow into the Old Brahmaputra-Lakhya is spill from Jamuna-Brahmaputra just upstream of Bahadurabad.

The physical setting and hydrology have produced a unique hydraulic regime, which creates a variety of difficulties for inhabitants. Flash floods are generated in the steep, upland catchments adjacent to the region in India. These flash floods spill onto low-lying floodplain lands in the region, inundating crops, damaging infrastructure by erosion and channel shifting, and often result in substantial quantities of coarse sand being deposited on agricultural land or in drainage channels. The main lowland rivers such as the Surma-Baulai, Kalni-Kushiyara, and Kangsha are currently adjusting their channel morphology in response to natural large-scale channel changes and the effects of past engineering works; embankment construction, distributary channel closures, and loop cutting. Many reaches on these rivers exhibit non-stationary trends in discharge and water levels. Past morphologic developments have often caused low-lying distributary channels in the deeply flooded Central Basin to be abandoned or obstructed, accompanied by gradual sediment infilling and obstruction of drainage.

Landforms, soils, and land use:

The Northeastern region comprised of six main landforms. They are:

1. The Sylhet Depression
2. Lowland Flood Plains
3. Piedmont Floodplains
4. Alluvial Fans
5. Terraces
6. Uplands

- ***The Sylhet Depression (Central Basin)*** is a low-lying bowl shaped basin covering about 25% of the region of 6,000 km^2. All of this land is below 8 m and is flooded to depths of 5 m and more during monsoon. Bowl shaped, seasonally flooded, interfluvial areas called Haor characterize this unit; the small permanent lakes in the lowest pockets are called Beel. The main rivers traversing the Depression include the Surma, Kalni, Kushiyara, Baulai, and Dhanu. These rivers are characterized by highly

sinuous, meandering sand-bed channels with cohesive banks. Channel shifting occurs erratically, and consequently the Depression is covered by a maze of ancient channel scars, abandoned distributaries, and oxbow lakes. Soils consist of grey of bluish grey clay, black herbaceous peat and yellowish grey silt. Alternating bed of peat and peaty clay are common in Beels and Haors. Historically, much of the depression was forested with Hijal *(Barringtonia racemosa)* and Koroch *(Pongamia pinnata)*, a key habitat for many species of fish, waterfowl, and other species.

- ***The Lowland Floodplains*** were created as a result of deposition and erosion from the Surma, Kushiyara, Meghna, Old Brahmaputra, and Jamuna Rivers. This landform covers about 55% of the region or 13,260 km^2. Land elevations typically range from 16m to 9m on the Surma/ Kushiyara floodplain, from 22m to 9m on the Old Brahmaputra floodplain, and less than 7m on the Meghna floodplain. This landform includes channel deposition such as point and bars and fills, over bank deposits such as natural leeves and crevasse splays, and fine-grained flood basin and back-channel deposits. The soils of the Surma/ Kushiyara floodplains are mainly alluvial silts and clays while the Old Brahmaputra floodplain consists of poorly stratified fine sandy to clayey silt.
- ***The Piedmont Floodplains*** are found along the tributary streams that join the larger mainstream rivers and cover about 4% of the region or 960 km^2. Land elevation range from 24m to 9m. Principal predominant streams include the Khowai, Manu, Sutang, Dhalai, and Juri Rivers which flow northwards from the Tripura Hills in India to join the Kushiyara River. Gradients of the streams are generally steeper than the mainstream rivers and are characterized by meandering sand-bed channels which have often developed natural levees of sand and silt.
- ***The Alluvial Fans*** are found along the foot of the Meghalaya Plateau and covers about 6% of the region or 1490 km^2. The fans result when Steep Mountain streams exit from their canyons and spread over the flat, unconfined land of the Lowland Floodplains and Sylhet Depression. Principal streams which have developed alluvial fans include the Someswari River, Jadukata River, and Dauki/ Piyain River. Typically, elevations range from 16m to 12m in the west and from 11m to 9m in the east.
- ***The Terraces*** along the western edge of the region and confine portions of the Old Brahmaputra River. This landform covers about 2% of the region or 500 km^2. It has

been raised by uplifting and faulting so it is no longer subject to inundation by normal flooding. Elevation ranges from 10m to 8m and the bsoils are comprised of Madhupur Clays.

- ***Uplands*** occur as outliers extending into the region from the Tripura hills and cover about 8%of the region or 1970 km^2. These hills are composed of weathered and poorly consolidated sandstone, siltstone, and conglomerate. Where the land has been left in its natural state, it has a cover of upland forests, thickets or grasses.

Water:

The principal catchments which drain from India into the regions are:

- Meghalaya Hills which from the northern boundary of Bangladesh and drain 13,466 km^2 of steep mountains along the southern face of Shillong Plateau.
- The Barak River basin which drains 25,263 km^2 in the states of Assam, Manipur and Mizoram
- Tripura Hills which drain an area of 6845 km^2 from the state of Tripura.

Total surface water supplies to the region excluding the Old Brahmaputra River are 173 km^3. Of this, 40% originates as rainfall over the region and 60% as rainfall over Indian catchments. An estimated 95% of the total surface water supply runs off during the period between May 1 and November 30. During this period tributary streams draining the Meghalaya and Tripura catchments are characterized by very flashy floods which rise to a peak in a day and recede in a day or two. These floods carry sediment loads are often accompanied by channel instability and erosion and can have a disastrous effect on the regions agriculture and infrastructure. However, even the main lowland rivers such as the Surma-Baulai, Kushiyara-Kalini and Meghna Rivers can display a very rapid rise and fall in water levels during flood times. The monsoon rise typically peaks between August and October. Almost 60% of the region principally, the Sylhet Depression, Sylhet Lowlands and Meghalaya Lowlands, may be inundated to a depth of 1m or more during the peak of the monsoon. This creates an aquatic environment which supports a vibrant open water fishery, an extensive inland water transport system and numerous other products and services.

Forestry:

Trees are found in four basic setting: upland natural forested areas, lowland natural forested areas (swamp forest), upland tea gardens, and homestead high land. The latter two types are cultivated.

Most upland natural forest areas in Sylhet Division are situated on low hills. These hills have a cover of evergreen trees combined with deciduous species. Additionally, these areas produce a variety of valuable species of bamboo and rattan including: *mitinga* Bambusa tulda, *pharu* B. plymorpha, *jalibet* Calamus tenius, and *gollabet* Daemonorops jenkinsian. Within the Mymensingh Division, the forest is mainly deciduous with *sal* Shorea robusta.

Remnant stands of lowland forest species (mainly *hijal, koroch, and barun* Crataeva nurvala) are still widely distributed and common in the wetland areas, as they provide several highly valued services. Strands of swamp forest trees protect homestead and embankment highlands from wave erosion.

5 CONCEPT OF WETLANDS

5.1 Definitions

5.1.1 Wetland

Wetlands have been defined in different ways by different organizations/authors. The definitions of wetlands mentioned in the Bangladesh Water Act, 2013 and that of the Ramsar Convention, 1971 have been given in Section 1.1. Some other definitions are given below:

- **Banglapedia (2003):**
  "Wetland is the low-lying ecosystem where the groundwater table is always at or near the surface. It includes areas of marsh, fen, bog, floodplain, and shallow coastal areas."

- **FGDC (Federal Geographic Data Committee) of USA Wetlands Classification Standard**:

  "Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil2; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year". (Cowardin et al.,1979)

- **"The Bangladesh Megacity, Divisional Town and Municipal Areas of District Towns and the Country's All the Municipal Area's Play Ground, Open Space, Garden and Natural Water Reservoir Conservation Act 2000 (Act 36 of 2000)" discusses natural reservoir as:**
  "Natural water reservoir means the area deleniated as river, canal (khal), beel, dighi (pond), spring (fountain) or water reservoir in the Master Plan or area declared by the Govt., local government or by any organization through gazette notification or flood plain and such land which contain water and rain water will also be include there in." (Natural Water Resources Act 2000)

- **Bangladesh Environment Conservation (Revised) Act 2010 (Act no 50 of 2010):** *Water reservoir means areas recorded as river, canal, beel, haor, baor, dighi, pond, spring (fountain) or water reservoir; or area declared by the Govt., local government or any government agency through government gazette notification as wetland (marshy land), flood plain and such land which contains water or rain water." (Act 50 of 2010)*

It may be observed that the term in Bangla 'জলাধার' has been translated as water reservoir in both the Acts. In fact, there is no difference of meaning between 'Water Reservoir' and 'Wetlands' as it appears from the descriptions.

The definition used by Govt. of Bangladesh as appeared in the Water Act 2013 and the definition of Ramsar Convention (1971) has been given in section 1.1.

As defined by the Ramsar Convention, wetlands include a wide variety of habitats such as marshes, peatlands, floodplains, rivers and lakes, and coastal areas such as saltmarshes, mangroves, and seagrass beds, but also coral reefs and other marine areas no deeper than six meters at low tide rivers and lakes irrespective of their depths, as well as human-made wetlands such as waste-water treatment ponds and reservoirs.

Among these definitions of wetlands, the one from Banglapedia is more focused but somewhat narrower in range of environment than FGDC or Ramsar definitions. The Ramsar definition of wetlands lumps together a wide range of contrasting habitats like fluvial, coastal and marine. The Bangladesh Water Act, 2013 definition focuses on hydrology of wetlands along with its plant habitat. Both the Act 36 of 2000 and Act 50 of 2010 indicate the legal connotation of the water reservoir (wetlands).

The Technical Committee of this project has advised to consider the Ramsar convention definition of wetlands for this study.

5.1.2 Definitions of Related Terms

- **Marsh** is an area of low-lying land that is flooded in wet seasons or at high tide, and typically remains waterlogged at all times.

- **Fen** is a low and marshy or frequently flooded area of land.

- **Bog** is a wet muddy ground too soft to support a heavy body.

- **Swamp** is an area of low-lying, uncultivated ground where water collects.

- **Peatland** is a wetland with a thick water-logged organic soil layer (peat) made up of dead and decaying plant material.

- **Pothole** is a deep natural underground cavity formed by the erosion of rock, especially by the action of water. In other words, it can be defined as a deep circular hole in a riverbed formed by the erosion of the rock by the rotation of stones in an eddy.

- **Shrub** is a woody plant that is smaller than a tree and has several main stems arising at or near the ground.

- **Sedge** is a grass like plant with triangular stems and inconspicuous flowers, growing typically in wet ground.

- **Karst** is the landscape underlain by limestone that has been eroded by dissolution, producing ridges, towers, fissures, sinkholes, and other characteristic landforms.

- **Dighi** is a man made big pond, where water remains throughout the year, excavated mainly for drinking water purposes.

5.2 Boundary of Wetlands (FGDC Classification System) [1]

The term 'System' refers to a complex of wetlands and deepwater habitats that share the influence of similar hydrologic, geomorphologic, chemical, or biological factors. Systems are further subdivided into more specific categories called 'Subsystems'. Wetlands are classified into five major Systems which are:

1. **Marine,**
2. **Estuarine,**
3. **Riverine,**
4. **Lacustrine and**
5. **Palustrine**

The major characteristics and limits of these five systems are discussed in the sections below.

5.2.1 Marine System

The Marine System (Figure 5.1) consists of the open ocean overlying the continental shelf and its associated high-energy coastline.

The Marine System extends from the outer edge of the continental shelf shoreward to one of three lines:

(1) The landward limit of tidal inundation (extreme high water of spring tides), including the splash zone from breaking waves;

(2) The seaward limit of wetland emergents, trees, or shrubs; or

(3) The seaward limit of the Estuarine System, where this limit is determined by factors other than vegetation. Deepwater habitats lying beyond the seaward limit of the Marine System are outside the scope of the WCS.

[1. Note: Excerpt from FGDC Classification of Wetlands and Deepwater Habitats of the United States, 2013]

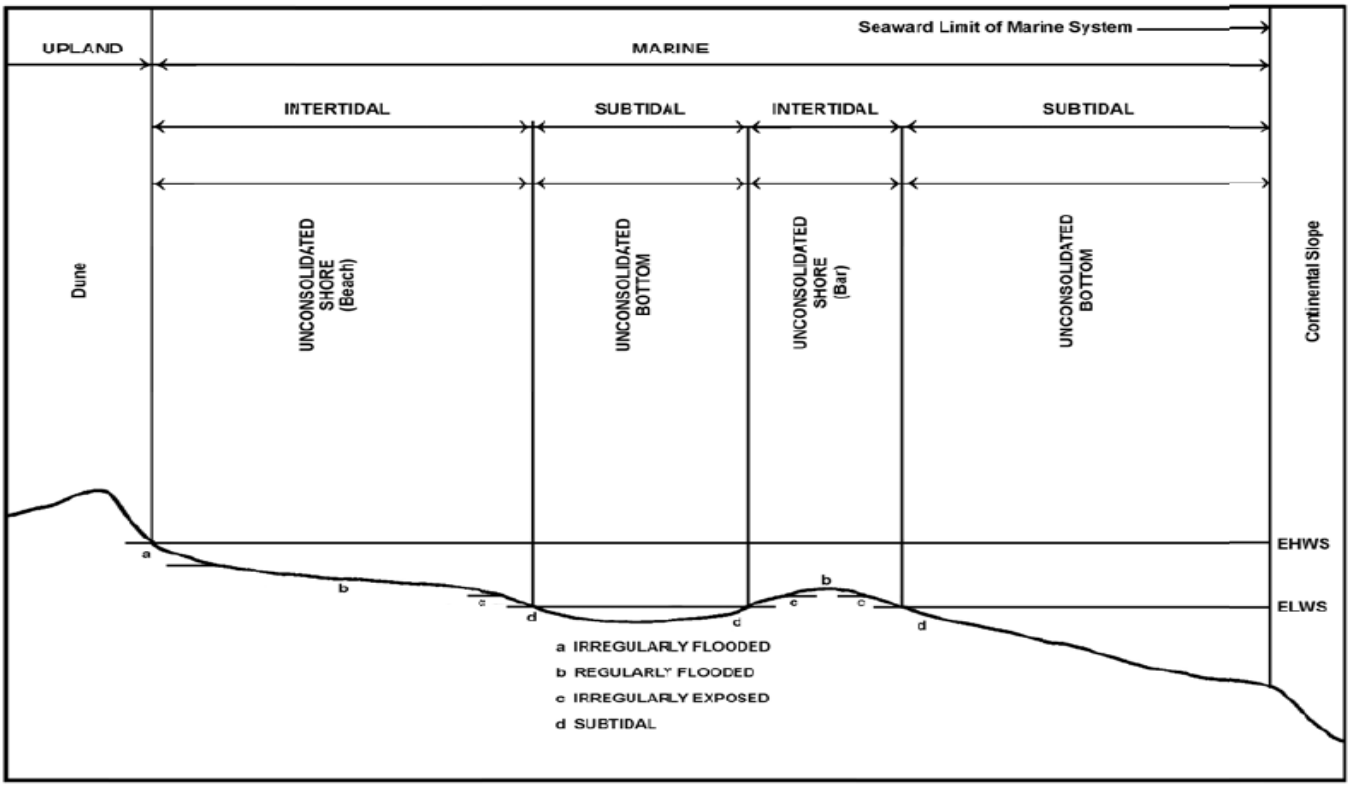


Figure 5.1: Distinguishing features in Marine System

[EHWS= Extreme high water of spring tides; ELWS= Extreme low water of spring tides]

5.2.2 Estuarine System

The Estuarine System (Figure 5.2) consists of deepwater tidal habitats and adjacent tidal wetlands that are usually semienclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land.

The Estuarine System extends upon:

(1) Upstream and landward to where ocean-derived salts measure less than 0.5 ppt during the period of average annual low flow;
(2) Seaward to an imaginary line closing the mouth of a river, bay or sound;
(3) To the seaward limit of wetland emergent, shrubs, or trees where they are not included in (2).

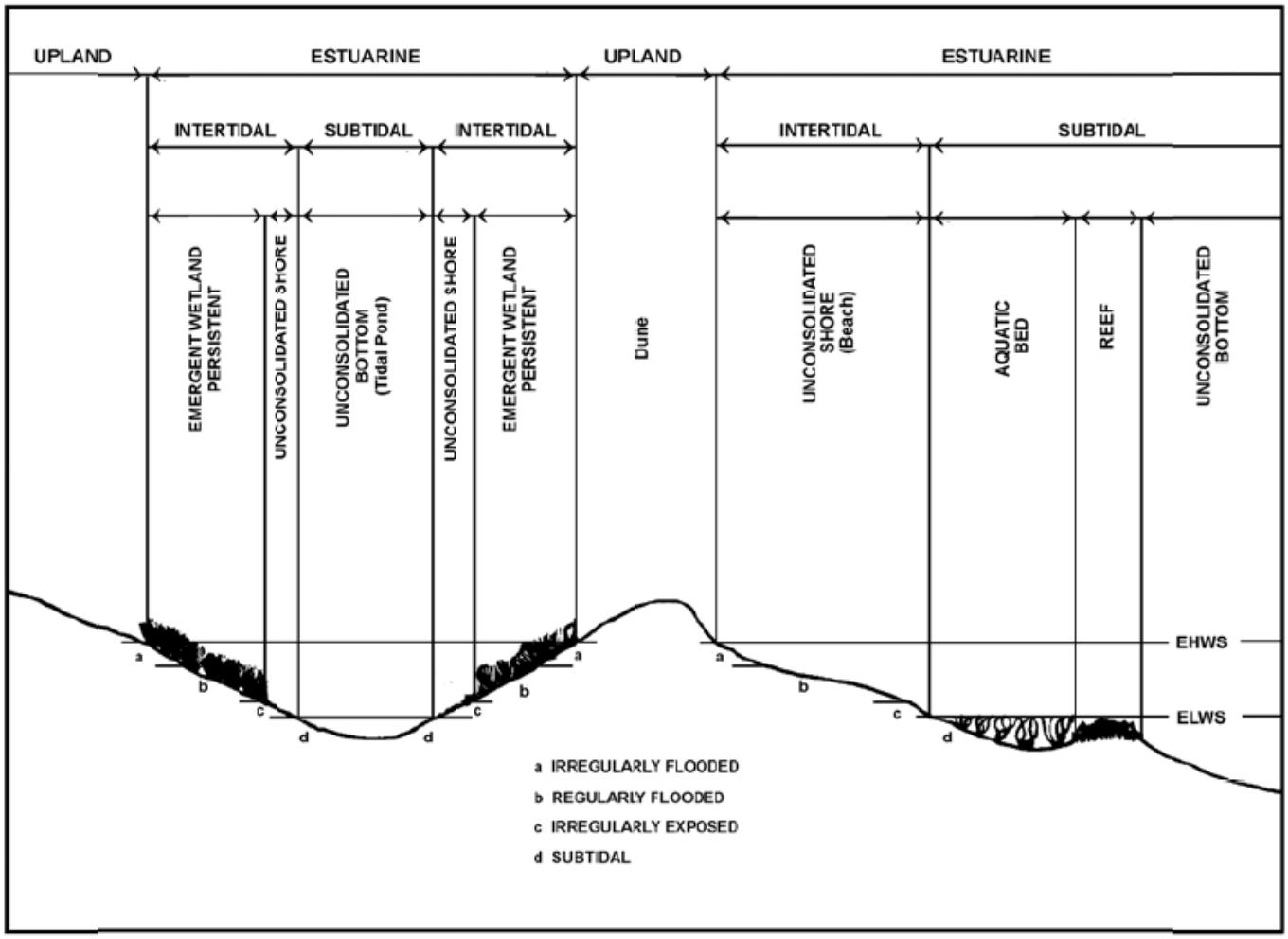


Figure 5.2: Distinguishing features in Estuarine System

[EHWS= Extreme high water of spring tides; ELWS= Extreme low water of spring tides]

5.2.3 Riverine System

The Riverine System (Figure 5.3) includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts of 0.5 ppt or greater.

The Riverine System is bounded on the landward side by upland, by the channel bank (including natural and man-made levees), or by wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. In braided streams, the System is bounded by the banks forming the outer limits of the depression within which the braiding occurs.

The Riverine System terminates at the downstream end where the concentration of ocean derived salts in the water equals or exceeds 0.5 ppt during the period of annual average low

flow, or where the channel enters a lake. It terminates at the upstream end where tributary streams originate, or where the channel leaves a lake. Springs discharging into a channel are considered part of the Riverine System.

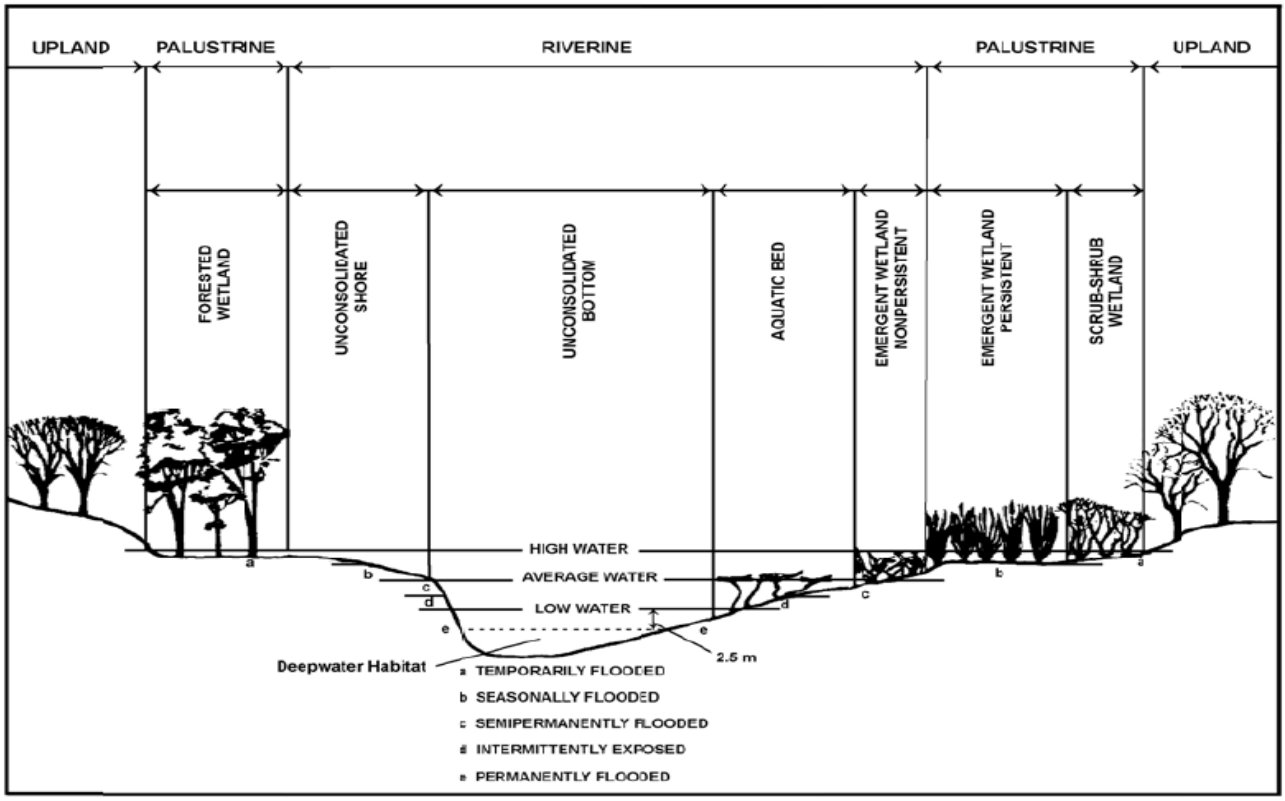


Figure 5.3: Distinguishing features in Riverine System

[EHWS= Extreme high water of spring tides; ELWS= Extreme low water of spring tides]

5.2.4 Lacustrine System

The Lacustrine System (Figure 5.4) includes wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mossesor lichens with 30 percent or greater areal coverage; and (3) total area of at least 8hectares (ha) (20 acres).

The Lacustrine System is bounded by upland or by wetlands dominated by trees, shrubs, persistent emergent, emergent mosses, or lichens. Lacustrine Systems formed by damming a river channel are bounded by a contour approximating the normal spillway elevation or normal pool elevation, except where Palustrine wetlands extend lakeward of that boundary. Where a river enters a lake, the extension of the Lacustrine shoreline forms the Riverine-Lacustrine boundary.

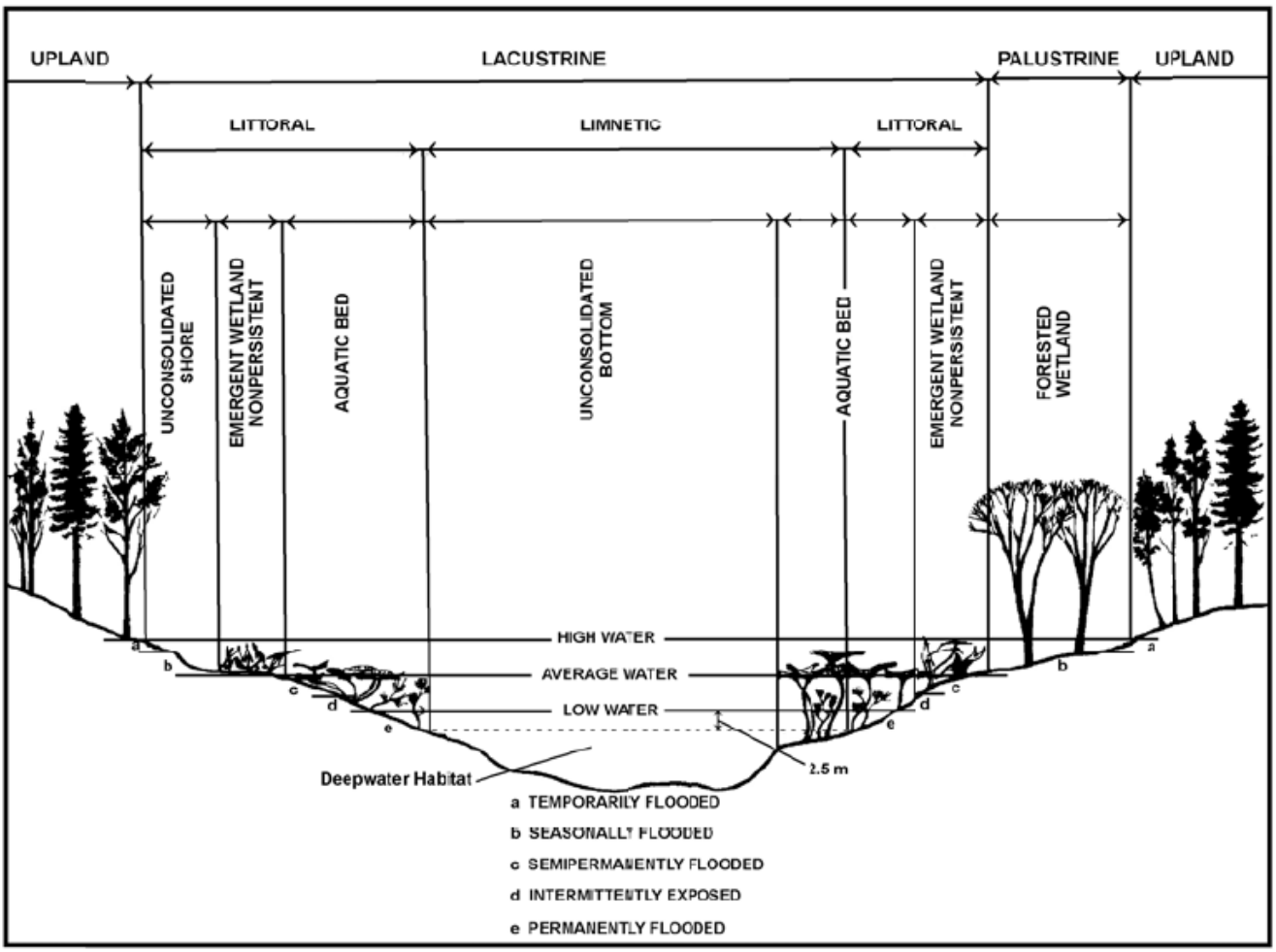


Figure 5.4: Distinguishing features in Lacustrine System

[EHWS= Extreme high water of spring tides; ELWS= Extreme low water of spring tides]

5.2.5 Palustrine System

The Palustrine System (Figure 5.5) includes all nontidal wetlands dominated by trees, shrubs, persistent emergent, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 ppt.

The Palustrine System is bounded by upland or by any of the other four systems.

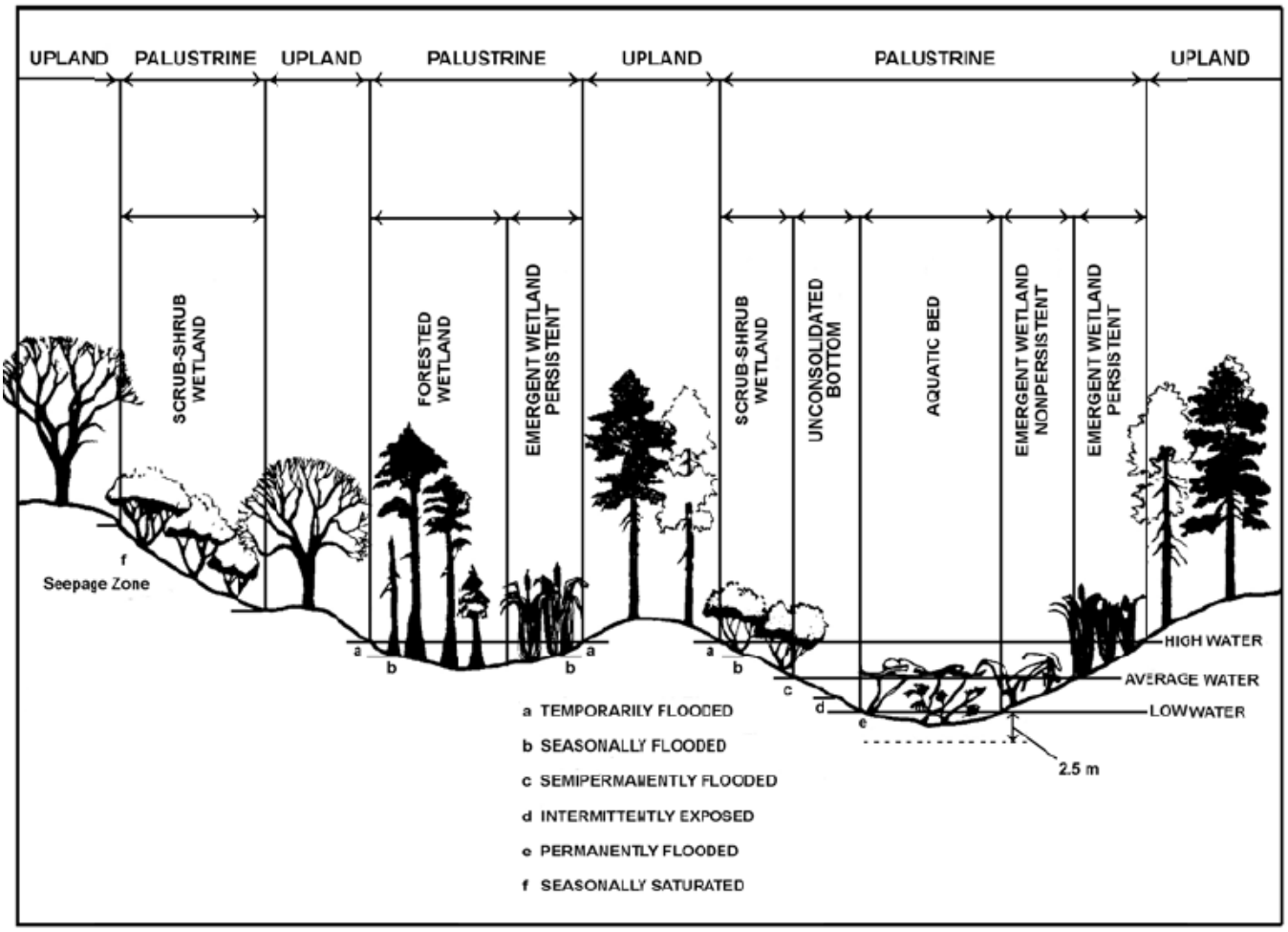


Figure 5.5: Distinguishing features in Palustrine System

[EHWS= Extreme high water of spring tides; ELWS= Extreme low water of spring tides]

5.3 Importance of Wetlands

Wetlands are among the world's most productive environments. They are cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals depend for survival. Wetlands perform a wide array of ecological services that mankind have only recently begun to appreciate. The major importance of wetlands are listed below:

Environmental importance:

- Wetlands support high concentrations of birds, mammals, reptiles, amphibians, fish and invertebrate species.

- Wetlands also release vegetative matter into rivers, which helps feed fish in the rivers.
- Wetlands help to counter balance the human effect on rivers by rejuvenating them and surrounding ecosystems.
- They also help to reduce the impacts from storm damage and flooding, maintain good water quality in rivers, recharge groundwater, store carbon, help to stabilize climatic conditions and control pests.
- Wetlands prevent flooding by holding water much like a sponge. This way, wetlands help to keep river levels normal and filter and purify the surface water.
- Wetlands also accept water during storms and whenever water levels are high. When water levels are low, wetlands slowly release water.
- Wetlands cover about 9% of the earth's surface and are estimated to contain around 35% of global terrestrial carbon. Wetlands act as sinks for carbon dioxide and other greenhouse gases, especially if their vegetation is protected and their natural processes are maintained. Coastal wetlands, such as saltmarsh and mangroves, are likely to have the highest rates of greenhouse gas sequestration. [Office of Environment and Heritage, NSW Govt., Australia]
- The interactions of physical, biological and chemical components of a wetland, as part of the "natural infrastructure" of the planet, such as soils, water, plants and animals, enable the wetland to perform many vital functions, for example, water storage; storm protection and flood mitigation; shoreline stabilization and erosion control; groundwater recharge and discharge; water purification; retention of nutrients, sediments, and pollutants; and stabilization of local climate conditions, particularly rainfall and temperature.
- At the coastal areas, the roots of wetland plants bind the shoreline together, resisting erosion by wind and waves and providing a physical barrier that slows down storm surges and tidal waves, thereby reducing their height and destructive power.
- When winter sets in across the northern hemisphere, it triggers the most extraordinary mass movement of any living creature on Earth - the annual migration of countless birds over vast distances. The world's wetlands offer a welcome refuge, offering protection and food before the birds continue on to their final destination.

Economic Importance:

- The most substantial benefits that accrue to a wide group of the population as well as to economic actors are related to the regulating services such as the flood preventing capacity of the native wetland.
- Wetlands also provide tremendous economic benefits, including water supply (quantity and quality); fisheries; agriculture, through the maintenance of water tables and nutrient retention in floodplains; timber and other building materials; energy resources, such as peat and plant matter; wildlife resources; transport; a wide range of other wetland products, including herbal medicines; and recreation and tourism opportunities.
- Over two thirds of the world's fish harvest is linked to the health of wetland areas.
- Wetlands are also important storehouses of plant genetic material. Rice, for example, which is a common wetland plant, is the staple diet of more than half of humanity.
- Coastal wetlands – such as reefs, mangroves and saltmarshes – act as frontline defence against potential cyclones and tidal waves which can minimize a lot of economic losses as well as many lives.
- Wetlands yield fuelwood for cooking, thatch for roofing, fibers for textiles and paper making, and timber for building.
- Plants of wetlands provide bark, leaves, and fruits from which medicines are extracted, and they also provide tannins and dyes, used extensively in the treatment of leather.

Agricultural Importance: Wetlands have been used for agriculture in Bangladesh for thousands of years. They provide a range of valuable services to agriculture, such as the retention and the cycling of nutrients. However, the value of these services is often underestimated. The drainage and reclamation of wetlands for agriculture has been widespread in Bangladesh, but there is increasing recognition of the critical interdependencies between agriculture and healthy wetlands. Wetlands can provide the following benefits to agriculture:

- Support fertile soils, reduce erosion and retain sediments and nutrients as well as reduce the potential for salinity and acid sulphate soils.
- Support aquaculture or grazing.

- Provide habitat for harvestable plant and animal species.
- Provide drinking water.
- Provide shade, wind buffering, protection from floods and habitat for birds.
- Provide a range of raw products such as timber, stock fodder, salt etc.
- Assist in drought resilience in North-west region of Bangladesh.

In addition to the above mentioned services, wetlands also have special contributions to the cultural heritage of humanity – they are related to religious and cosmological beliefs and spiritual values, constitute a source of aesthetic and artistic inspiration, yield invaluable archaeological evidence from the remote past, provide wildlife sanctuaries, and form the basis of important local social, economic, and cultural traditions.

Throughout the history, wetlands have suffered at the hands of humans. Due to the indifference, exploitation, or misguided views, humans have damaged or destroyed most of world's wetlands. And even now, in spite of the awareness of the ecological importance of wetlands, the degradation continues, and hundreds of acres of wetlands are lost per year. Although wetlands play a major and important role in our ecology and biodiversity, the rate of loss and deterioration of wetlands is accelerating in all regions of the world. The pressure on wetlands is likely to intensify in the coming decades due to increased global demand for land and water, as well as climate change. One of the key and underlying issues is concern about endangered species: More than one third of endangered species live only in wetlands and almost half use them at some time during their lifecycles. As wetlands bear such great economic and ecological values and provide us with such vast ecological services, it is of utmost importance to conserve them and keep the biodiversity intact.

It should be noted that these functions, values, and attributes that wetlands provide (i.e. **"ecosystem services"** and **"components"**) can only be maintained if the ecological processes of wetlands are allowed to continue functioning. In order to do that, conservation and restoration of the environment and habitats of the wetlands need to be carried out.

For Bangladesh, wetlands bear much importance than any other parts of the world. The country is ravaged by severe floods almost every monsoon season. Wetlands can provide some extent of flood reduction by holding the excess runoff after a storm, and then releasing it slowly. While wetlands cannot prevent flooding, they can lower flood peaks by temporarily

holding water and by slowing the water's velocity. Wetland soil acts as a sponge, holding much more water than other soil types.

The Govt. of Bangladesh has grasped the importance and the immense possibilities of wetlands. In both MDG (Millennium Development Goal) and SDG (Sustainable Development Goal), the importance of wetlands has been mentioned. As Bangladesh is a signatory of the MDG and SDG, it is absolutely necessary to understand the importance of wetlands. Wetlands and its vast biodiversity is the one of the main focuses of Goal 6, Goal 14 and Goal 15 in the Sustainable Development Goal (SDG). The Goal 6 requires to 'Ensure access to water and sanitation for all', which is one of the major functions of wetlands. The approved PSP of the Project also highlighted the importance of the wetlands as:

"Wetlands are essential breeding, rearing, and feeding grounds for many species of fish and wildlife. They may also perform important flood protection and pollution control functions. Increasing National and international recognition of these values has intensified the need for reliable information on the status and extent of wetland resources. To develop comparable information over large areas, a clear definition and classification of wetlands is required."

The importance of protection and safeguard of the wetlands have been mentioned in the Article 18.A of the Constitution of Bangladesh.

"The state shall endeavor to protect and improve the environment and to preserve and safeguard the natural resources, biodiversity, wetlands, forests and wild life for the present and future citizens." (Constitution of Bangladesh, Act 18.A)

Moreover, Bangladesh is a signatory of the Ramsar Convention. Ramsar Convention on wetlands came in force for Bangladesh on 21 September, 1992. Considering the importance of wetlands, Bangladesh has formulated several acts and rules. Some of them are listed below:

1. Bangladesh Water Act, 2013
2. National River Protection Commission Act, 2013
3. The Bangladesh Megacity, Divisional Town and Municipal Areas of District Towns and the Country's All the Municipal Area's Play Ground, Open Space, Garden (Park) and Natural Water Reservoir Conservation Act, 2000
4. The Canal Act, 1864

5. Bangladesh Environmental Protection Act, 1995
6. Bangladesh Environmental Protection Act (Revised), 2010
7. National River Protection Commission Act, 2013

Although there is no specific policy for wetlands but Water Policy (1999) has specific sections on wetlands. Other national policies such as Environment (1992), Fish (1998), Forest (1994), Coastal Zone Policy (2005) and Agriculture (1999) have directives about water bodies.

For the purpose of conservation, protection and restoration of ecosystems of areas which due to degradation of environment have reached or threatened to be reached to a 'critical state', Government of Bangladesh has declared them 'Ecologically Critical Areas (ECA)'. It may be noted that Bangladesh has so far declared 13 ECAs (upto 2015), all of which are wetlands. The list of Ecologically Critical Areas of Bangladesh is given in Table 5.1. The 'Type of wetlands' column refers to the Classification System of Wetlands of Bangladesh (please see Table 7.2 for details). The map of Ecologically Critical Areas of Bangladesh is given in Figure 5.6.

Table 5.1: Ecologically Critical Areas (ECAs) of Bangladesh

Sl. No.	Name of ECA	Type of Ecosystem	Location	Areas (ha)	Year of Declaration
1.	Cox's Bazaar-Teknaf Peninsula	Coastal-Marine	Cox's Bazar	20,373	1999
2.	Sundarbans (10 km landward periphery)	Coastal-Marine	Bagerhat, Khulna & Satkhira	292,926	1999
3.	St. Martin's Island	Marine Island with coral reefs	Teknaf upazila, Cox's Bazar	1,214	1999
4.	Hakaluki Haor	Inland Frestwater Wetland	Sylhet and Moulvi Bazar	40,466	1999
5.	Sonadia Island	Marine Island	Moheshkhali upazila, Cox's Bazar	10,298	1999
6.	Tanguar Haor	Inland Frestwater Wetland	Moulvi Bazar	9,727	1999
7.	Marjat Baor	Oxbow Lake	Kaliganj upazila of Jhenaidah & Chaugacha upazila of Jessore	325	1999
8.	Gulshan-Baridhara Lake	Urban Wetland	Dhaka city	101	2001
9.	Buriganga	River	Around Dhaka	1336	2009
10.	Turag	River	Around Dhaka	1184	2009
11.	Sitalakhya	River	Narayanganj, Dhaka, Gazipur	3771	2009
12.	Balu including Tongi canal	River	Around Dhaka	1315	2009
13.	Jaflong-Dawki	River	Jaflong, Sylhet	1493	2015
			Total	**3,84,529 ha**	

[Source: Adapted from DoE, 2015]

[Note: 'Type of wetlands' column refers to the Classification System of Wetlands of Bangladesh. Please see Table 7.2 for details.]

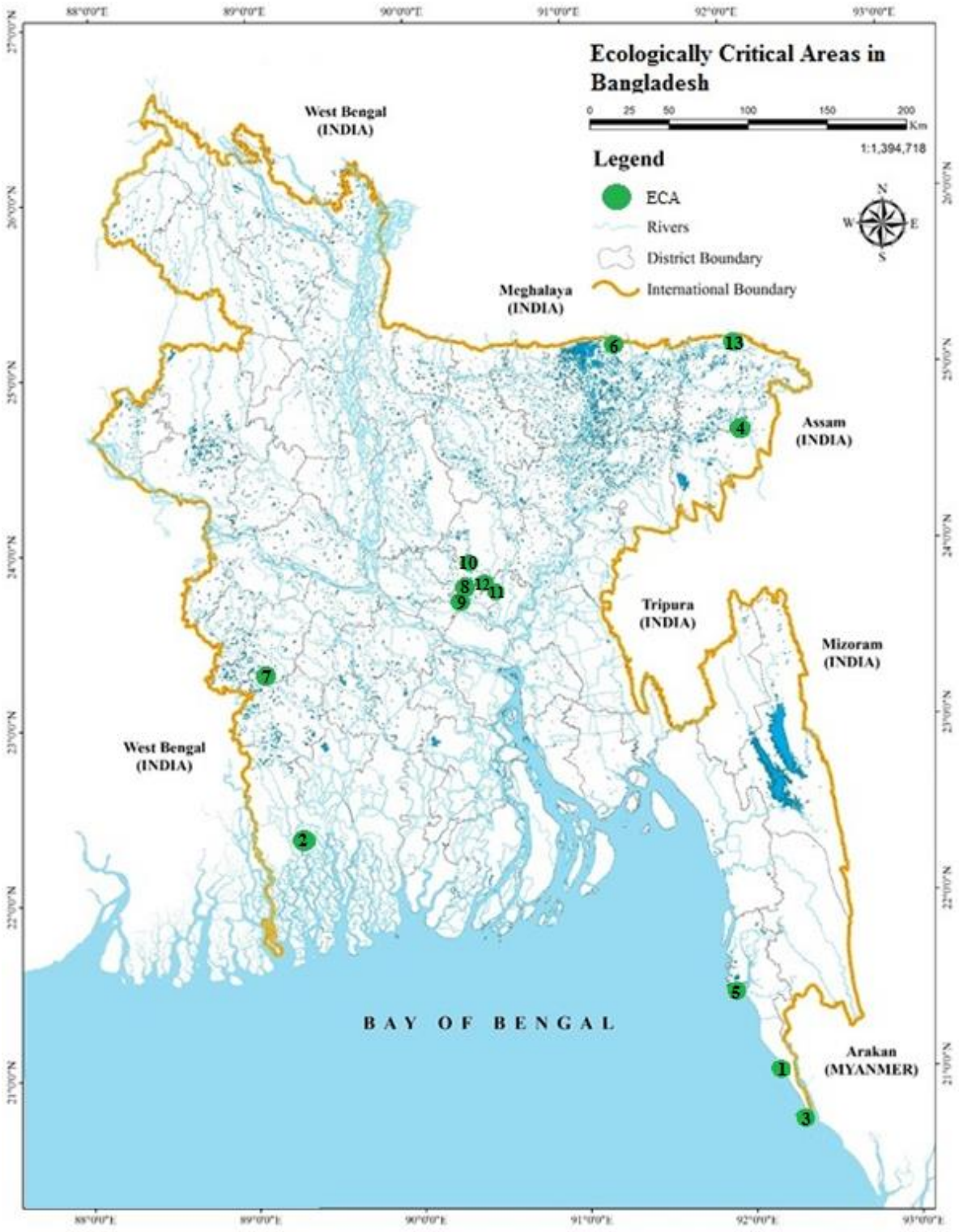


Figure 5.6: Ecologically Critical Areas (ECA) of Bangladesh (Source: adapted from CREL - BCAS, 2015)

5.4 Importance of Classification System

The classification of wetlands helps to identify and categorize each wetland in a country. This can help us to identify vulnerable wetlands and conserve them. The Systems and Subsystems in the classification system are most important in applications involving large regions or the entire country. They serve to organize the Classes into meaningful assemblages of information for data storage and retrieval *(Ramsar, 1971).*

Wetlands are most vulnerable from both over-exploitation for economic gains and degradation of wetland environment. If it is intended that wetlands should continue to perform their ecological functions, then they have to be protected. For conservation purposes, in depth knowledge of the wetlands and their habitats is required. Forestation of a degraded wetland, the basic parameters of the wetland and its habitats need to be known. The classification system provides the necessary information and parameters of a wetland, so that the conservation and restoration process can be taken up.

Another purpose of the classification is to extend the existing knowledge base of wetlands, for ensuring sustainable use of the ecological services of the wetlands.

The wetland classification system, developed under this study will be used in the development of future Wetland Database and National Wetland Inventory. Data and information generated under this study is intended for use in the planning and decision making process, to prevent or minimize the adverse impact of development on fish and wildlife i.e. to minimize adverse environmental impacts. The database will help the policy makers/Government in intensifying their activities in preservation and protection of natural resources and making a balance between the development options and degradation of natural resources. The data may also be used for designing restoration programs. This way, Bangladesh will be able to fulfill its commitment towards enhancement of environmental quality both at national and international levels.

6 DATA COLLECTION AND ANALYSIS

Data on aquatic plants, animals, fisheries and soil types have been collected from both primary and secondary data sources. The data collected from both the primary and secondary sources have been analyzed and compiled in a number of annexures. The list of Annexures are:

- Annexure 1: Rivers of Bangladesh
- Annexure 2: Haors of Bangladesh
- Annexure 3: Maps of Wetlands of Bangladesh
- Annexure 4: Beels of Bangladesh
- Annexure 5: Reversible Wetlands
  - 5A: List of Polders of Bangladesh
  - 5B: List of FCD projects of Bangladesh
- Annexure 6: Biodiversity of Wetlands of Bangladesh
  - 6A: Plants of Inland Wetlands
  - 6B: Plants of Sundarban Mangrove Forest
  - 6C: Plants of Tanguar Haor
  - 6D: Birds of Tanguar Haor
  - 6E: Animals of Tanguar Haor
  - 6F: Freshwater Fishes of Bangladesh
- Annexure 9: Soil Information of Wetlands of Bangladesh
- Annexure 10: Wetland Photo Gallery

6.1 Primary Data

Data on soil parameters and data on flora are some of the data which have been included in the primary database. The data on soil and flora have been collected in the format prepared during the inception report. The synthesized data is presented in the Annexures of the Final Report. The list of primary data is:

1. Soil information
2. Aquatic Plants
3. Birds
4. Animals
5. Fisheries

The primary data have been collected and used for something close to spot checking or validation of the secondary data.

6.2 Secondary Data

As mentioned earlier, the secondary data have been collected from various departments and published documents. The data list includes:

1. Haors
2. Rivers
3. Beels
4. Perennial Waterbodies
5. Satellite Images (monsoon and dry season)
6. Plants of Wetlands of Bangladesh
7. Plants of Sundarban
8. Plants of Tanguar Haor
9. Birds of Tanguar Haor
10. Animals of Tanguar Haor
11. Coastal Polders
12. Major FCD Projects

The data were synthesized and several annexures were prepared which indicate different characteristics of the wetlands. A brief discussion is given in the following section.

6.3 Data Analysis and Results

6.3.1 Aquatic Plants

Primary data on aquatic plants were collected by enumerators. The data have been collected by discussing with local people and taking photographs of the sample. Most of the information were collected from secondary sources such as Encyclopedia of Flora and Fauna (Asiatic Society of Bangladesh), Master Plan of Haor Areas, 2012 and publications of IUCN Bangladesh. The data from secondary sources have been spot checked. The data were also cross checked with the photographs taken during primary data collection.

Analyzing and compiling these data, **Annexure 6: Biodiversity of Wetlands of Bangladesh** has been prepared. It may be mentioned that this Annexure 6 does not reflect the whole scenario of biodiversity of the wetlands (beyond the scope of the TOR). The Annexure 6

focuses on the plants of inland wetlands (Annexure 6A) and freshwater fishes of wetlands of Bangladesh (Annexure 6F). Plant diversity of the Sundarbans (a Ramsar site) has been presented as Annexure 6B. Moreover, diversity of plants, birds and animals of a specific haor named Tanguar Haor (a Ramsar site) have been presented as Annexure 6C, 6D and 6E respectively. Sample pages from Annexure 6A, 6B and 6C is shown below in the following boxes (Box 6.1, 6.2 and 6.3 respectively).

Figure 6.1: Golpata
Nypa Fruticans

Figure 6.2: Lal Shapla (Red Water Lily)
Nymphaea rubra

Figure 6.3: Kochuri pana (Water Hyacinth)
Eichhornia crassipes

Serial No.	Scientific name	English name	Local/Bangla mame
1	*Alternanthera ficoidea*	Not known	Not known
2	*Alternanthera philoxeroides*	Alligator weed	Hycha
3	*Alternanthera sessilis*	Alligator weed	Hycha
4	*Aniseia martinicensis*	White Jacket	Rada lota
5	*Aponogeton undulatus*	Not known	Not known
6	*Aponogeton nutans*	Not known	Not known
7	*Asparagus racemosus*	Wild Asparagus	Satamuli.
8	*Azolla filiculoides*	Water Fern	Lal Khudipana
9	*Azolla pinnata*	Feathered mosquito fern	Khode pana
10	*Barringtonia acutangula*	Indian Oak	Hijol
11	*Calamus longisetus*	Rattan palms	Bet
12	*Cardiospermum halicacabum*	Balloon Vine	Phutka
13	*Centella asiatica*	Indian pennywort.	Thankuni
14	*Ceratophyllum demersum*	Hornwort	Not known
15	*Ceratopteris thalictroides*	Water fern	Pani Dhekia
16	*Chenopodium album*	Pigweed	Beley shak.
17	*Chylocalyx perfoliatus*	Thorny Smartweed.	Kanta Tokpata
18	*Cissampelos pareira var. hirsute*	Not known	Akanadi
19	*Cleome hassleriana*	Fringed spider flower	Not known
20	*Clerodendrum indicum*	Not known	Not known

Box 6.1: A sample page of Annexure 6A: Plants of Inland Wetlands

Serial No.	Scientific Name	Family	Vernacular Name	Habits
1.	*Acanthus ilicifolius*	Acanthaceae	Hargoza	Scrambling herb
2.	*Acrostichum aureum*	Pteridiaceae	Hodo, tiger fern	Gregarious fern
3.	*Aegialitis rotundifolia*	Plumbaginaceae	Dhalchaka	Small tree
4.	*Aegiceras coriculatum*	Myrsinaceae	Khalisha, Khalshi	Shrub or small tree
5.	*Amoora cucullata*	Meliaceae	Amur	Small tree
6.	*Avicennia alba*	Avicenniaceae	Sada baen	Small tree
7.	*Avicennia marina*	Avicenniaceae	Morcha baen	Small tree
8.	*Avicennia officinalis*	Avicenniaceae	Baen	Tree
9.	*Barringtonia racemosa*	Barringtoniaceae	Kumba, Kumbi	Small tree
10.	*Blumea amplectens*	Compositae	Hash	Aromatic herb
11.	*Brownlowia tersa*	Tiliaceae	Ota sundri	Climbing shrub
12.	*Bruguiera gymnorrhiza*	Rhizophoraceae	Kankra	Tree
13.	*Caesalpinia crista*	Leguminosae	Kutum katta	Climbing armed shrub
14.	*Cerbera manghas*	Apocynaceae	Dagor	Small tree
15.	*Ceriops decandra*	Rhizophoraceae	Goran	Shrub or small tree
16.	*Clerodendrum inerme*	Verbenaceae	Sitka, Sitki	Climbing shrub
17.	*Cynometra ramiflora*	Leguminosae	Shingra	Shrub
18.	*Cyperus javanicus*	Cyperaceae	Kucha, Kusha	Sedge
19.	*Dalbergia candenatensish*	Leguminosae	Chanda lota	Scrambling climber
20.	*D. spinosa*	Leguminosae	Chanda katta	Climbing armed shrub
21.	*Imperata cylindrical*	Gramineae		Grass
22.	*Intsia bijuga*	Leguminosae	Bhaela, Bharal	Small tree
23.	*Ipomoea pes-caprae*	Convulvulaceae	Gash	Succulent herb
24.	*Ixora* sp.	Rubiaceae	Bon bakul	Small tree

Box 6.2: A sample page of Annexure 6B: Plants of Sundarban Mangrove Forest

Serial No	Scientific Name	English Name	Local/Bangla Name
1.	*Alternanthera ficoidea*	Not known	Not known
2.	*Alternanthera philoxeroides*	Alligator weed	Hycha
3.	*Alternanthera sessilis*	Alligator weed	Hycha
4.	*Aniseia martinicensis*	White Jacket	Rada lota
5.	*Aponogeton undulatus*	Not known	Not known
6.	*Aponogeton nutans*	Not known	Not known
7.	*Asparagus racemosus*	Wild Asparagus	Satamuli.
8.	*Azolla pinnata*	Feathered mosquito fern	Khode pana
9.	*Barringtonia acutangula*	Indian Oak	Hijol
10.	*Calamus longisetus*	Rattan palms	Bet
11.	*Cardiospermum halicacabum*	Balloon Vine	Phutka
12.	*Centella asiatica*	Indian pennywort.	Thankuni
13.	*Ceratophyllum demersum*	Hornwort	Not known
14.	*Chenopodium album*	Pigweed	Beley shak.
15.	*Chylocalyx perfoliatus*	Thorny Smartweed.	Kanta Tokpata
16.	*Cissampelos pareira var. hirsuta*	Not known	Akanadi
17.	*Cleome hassleriana*	Fringed spider flower	Not known
18.	*Clerodendrum indicum*	Not known	Not known
19.	*Coccinia grandis*	Ivy Gourd	Telakucha
20.	*Coix lacryma-jobi*	Job's Tears	Kaich Gota

Box 6.3: A sample page of Annexure 6C: Plants of Tanguar Haor

6.3.2 Birds

Data on birds of Tanguar Haor have been collected in the format prepared in consultation with the DBHWD. The data have been collected through discussion with local people and taking photographs. Most of the information have been collected from secondary sources such as Encyclopedia of Flora and Fauna (Asiatic Society of Bangladesh) and different publications of IUCN Bangladesh.

Analyzing and compiling these data, **Annexure 6D: Birds of Tanguar Haor** has been prepared. Sample pages of Annexure 6D is shown below in Box 6.4.

Figure 6.4: Choto Machranga (Common Kingfisher)
Alcedo atthis

Figure 6.5: Raj Sorali (Fulvous Whistling Duck)
Dendrocygna bicolor

Figure 6.6: Doyel (Oriental Magpie Robin)
Copsychus saularis

Serial No.	English Name	Scientific Name	Local/Bangla Name
1.	Fulvous Whistling Duck	*Dendrocygna bicolour*	Raj Sorali
2.	Lesser Whistling Duck	*Dendrocygna javanica*	Sorali, Pati Sorali
3.	Greylag Goose	*Anser anser*	Mete Rajhas, Dhushor Rajhans
4.	Bar-headed Goose	*Anser indicus*	Rajhans, Dagi Rajhas
5.	Ruddy Shelduck	*Tadorna ferruginea*	Chokachoki, Khaira Chokachoki
6.	Common Shelduck	*Tadorna tadorna*	Pati chokachoki, Shah Chokha
7.	Knob-billed Duck	*Sarkidiornis melanotos*	Nakta Has
8.	Cotton Pygmy-goose	*Nettapus coromandelianus*	Dhola Bali Has, Bali Hans
9.	Gadwall	*Anas strepera*	Piong Hans
10.	Falcated Duck	*Anas falcata*	Shikhajukto Hans, Falcate Has
11.	Eurasian Wigeon	*Anas penelope*	Lalshir, Eurasio Shitihas
12.	Mallard	*Anas platyrhynchos*	Nilshir, Nilmatha Has
13.	Spot-billed Duck	*Anas poecilorhyncha*	Pati Hans, Deshi mete has
14.	Baikal Teal	*Anas formosa*	Baikal Tili Has, Boikal Hans
15.	Common Teal	*Anas crecca*	Patari Hans, Pati Tilihas
16.	Garganey	*Anas querquedula*	Giria Hans
17.	Northern Pintail	*Anas acuta*	Lenja Hans, Utture Lanja has
18.	Northern Shoveler	*Anas clypeata*	Pantamukhi, Utture Khunte Has
19.	Red-crested Pochard	*Netta rufina*	Rangamuri, Laljhuti Bhuti Has
20.	Common Pochard	*Aythya ferina*	Bamunia Hans, Pati Bhutihas

Box 6.4: A sample page of Annexure 6D: Birds of Tanguar Haor

6.3.3 Animals

Data on animals of Tanguar Haor have been collected. Primary data on animals are collected by enumerators in the format prepared in consultation of the DBHWD. The data were collected by discussing with local people and taking photographs. Most of the information are collected from secondary sources such as IUCN Bangladesh.

Analyzing and compiling these data, **Annexure 6E: Animals of Tanguar Haor** has been prepared. Sample pages of Annexure 6E is shown below in Box 6.5.

Figure 6.8: Kuno Bang (Asian Common Toad)
Duttaphrynus melanostictus

Figure 6.9: Kori Kaitta (Indian Roofed Turtle)
Pangshura tecta

Figure 6.7: Shial (Golden Jackal)
Canis aureus

Serial No.	English Name	Scientific Name	Local/Bangla Name
Mammals			
1.	Asian House Shrew	*Suncus murinus*	Chika/ Chhucha
2.	Flying Fox	*Pteropus giganteus*	Badur/ Champ
3.	Indian Pipistrelle	*Pipistrellus coromandra*	Chamchika
4.	Indian Pangolin	*Manis crassicaudata*	Banrui/Pipilika bhuk
5.	Golden Jackal	*Canis aureus*	Pati Shial/Shial
6.	Bengal Fox	*Vulpes bengalensis*	Khek Shial
7.	Jungle Cat/ Swamp Cat	*Felis chaus*	Ban Biral/Woab
8.	Fishing Cat	*Prionailurus viverrinus*	Mechho Biral/ Mechho Bagh
9.	Small Indian Mongoose	*Herpestes javanicus*	Benji/Nakul
10.	Smooth Coated Otter	*Lutrogale perspicillata*	Mosrin Ud/Ud Biral/ Bhodar
11.	Wild Boar	*Sus scrofa*	Buno Shukar/ Shuar
12.	Small Indian Civet	*Viverricula indica*	Khatash/Kolkut
13.	Three-striped Palm Squirrel	*Funambulus palmarum*	Teen-Dora Kathbirali
14.	Lesser Bandicoot Rat	*Bandicota bengalensis*	Indur
15.	Greater Bandicoot Rat	*Bandicota indica*	Bora Indur/Dhari Indur
16.	House Mouse	*Mus musculus*	Nengti Indur
17.	Common House Rat	*Rattus rattus*	Ghorer Indur
18.	Brown Rat/ Tree Rat	*Rattus norvigicus*	Gechho Indur
19.	Indian Porcupine	*Hystrix indica*	Shojaru

Box 6.5: A sample page of Annexure 6E: Animals of Tanguar Haor

6.3.4 Fisheries

Data on fisheries of Bangladesh have been collected from different wetlands of Bangladesh. Primary data on fisheries have been collected by enumerators in the format prepared in consultation with the DBHWD. The data have been collected by discussing with local people and taking photographs. Most of the information have been collected from secondary sources such as IUCN Bangladesh and Department of Fisheries.

Analyzing and compiling these data, **Annexure 6F: Freshwater Fisheries of Bangladesh** has been prepared. Sample pages from Annexure 6F is shown below in Box 6.6.

Figure 6.10: Ilish (Hilsha Shad)
Tenualosa ilisha

Figure 6.11: Rui (Rohu)
Labeo rohita

Figure 6.12: Chital (Clown Knife Fish)
Chitala chitala

Sl. No.	Scientific Name	English Name	Local Name	Status in Bangladesh	Global Status	Habitat
1.	*Anguilla bengalensis*	Indian Mottled Eel, Giant Molted Eel, Mottled Eel	Maow Baim	VU	NT	R
2.	*Pisodonophis boro*	Rice-Paddy Eel, Bengal's Snake-Eel, Snake Eel	Kharu	LC	LC	ET, R
3.	*Pisodonophis cancrivorus*	Estuary Snake Eel, Longfin Snake Eel, Snake Eel	Baim	LC	NE	ET
4.	*Oryzias melastigma*	Et Ricefish	Bechi	LC	LC	ET, PP
5.	*Oryzias carnaticus*	Spotted Ricefish	Bechi	DD	LC	ET, FP
6.	*Oryzias dancena*	Indian Ricefish/Ricefish	Bechi	DD	LC	ET, FP
7.	*Dermogenus brachynotopterus*	Gangetic Halfbeak	Ek Thota	DD	-	R, ET
8.	*Dermogenys pusillus*	Wrestling Halfbeak	Ek Thota	LC	-	R, ET
9.	*Hyporhamphus limbatus*	Congaturi Halfbeak	Ek Thuita	LC	NE	R, ET
10.	*Anodontostoma chacunda*	Shortnosed Gizzard Shad, Chacunda Gizzard Shad	Chacunda, Dombura, Koiputi	LC	NE	ET
11.	*Corica soborna*	Ganges River-Sprat	Kachki	LC	LC	R, FP
12.	*Gonialosa manmina*	Ganges River Gizzard Shad	Chapila, Goni Chapila	LC	LC	R, ET

Box 6.6: A sample page of Annexure 6F: Fisheries of Wetlands of Bangladesh

6.3.5 Soil Samples

Soil samples have been collected by enumerators from floodplains, located in 64 upazillas of 64 districts of Bangladesh. Samples have been collected from the top layer. Three samples were collected from each location to obtain an average of the composition.

The soil samples have been collected and analyzed in the Prosoil laboratory located in Uttara, Dhaka for the following:

- Soil Composition (texture): Clay, Sand and Silt content
- Chemical Composition: Nitrogen (N), Phosphorus (P), Potassium (K) and pH

Determining of Soil Composition (Texture):

- **Sieve Analysis:** Sieve analysis was performed by means of sieving (ASTM D 422). Sieve analysis is done for determination the amount of silt and sand content in the sample. For oven-dry materials, sieving was carried out for particles retained on a 0.075 mm sieve. In sieve analysis, the mass of soil retained on each sieve is determined and expressed as a percentage of the total mass of the sample.
- **Hydrometer Test:** Hydrometer analysis was done for obtaining the amount of clay percentage in the soil sample. Hydrometer analysis is based on the principle of sedimentation of soil grains in water. When a soil specimen is dispersed in water, the particles settle at different velocities, depending on their shape, size, and weight. For simplicity, it is assumed that soil particles are spheres and the velocity of soil particles can be express by Stokes' law. The results have been expressed as percentage of the total mass of the sample.

Determination of Chemical Composition:

- **Determination of Available Nitrogen Content in Soil:** The available Nitrogen content in the soil was determined by Kjeldahl method. The result is expressed in percentage of Nitrogen content in the sample soil.
- **Determination of Available Phosphorus Content in Soils:** The available Phosphorus content was determined by Bray Method and Bray No 2 solution was used to extract adsorbed forms of phosphate only. The value is expressed in percentage of Phosphorus content in the sample soil.

- **Determination of Available Potassium Content in soils:** The potassium content of the soil is determined using a Jenway PFP7 Flame Photometer. Potassium is extracted from air-dried soil samples by shaking with 0.5M ammonium acetate/acetic acid solution for 30 minutes. This effectively displaces the potentially available K+ ions. The potassium content of the filtered extract is then determined using a Jenway PFP7 Flame Photometer. Normally the results are reported as ppm potassium in the extract.

The results of the physical and chemical properties of the soil samples have been compared with the SRDI determined values. The soil analysis details have been presented in the **Annexure 9: Soil of Wetlands of Bangladesh.** A sample page from the Annexure 9 is shown in Box 6.7.

District: Barguna

Soil Sample Collection Point	22° 8'2.07"N, 90°14'10.29"E
Upazilla	Amtali
Union	Chowra
Wetland Location	Floodplain of Amtali Don River
SRDI Map Unit Index	1

Physical Properties (Texture)	Observed Value	SRDI Value
Sand, %	78.18	<80
Silt, %	21.82	<72
Clay, %	0.0	20-40

Chemical Properties	Observed Value	SRDI Value
Nitrogen (N), %	0.11	0.09-0.21
Potassium (K), ppm	61-120	50.7-179.4
Phosphorus (P), mg/kg	6	5-32
pH	7.7	5.0-8.1

Box 1: Soil Information of Amtali Upazilla

Figure 1: Soil sample collection point of Amtali Upazilla of Barguna District

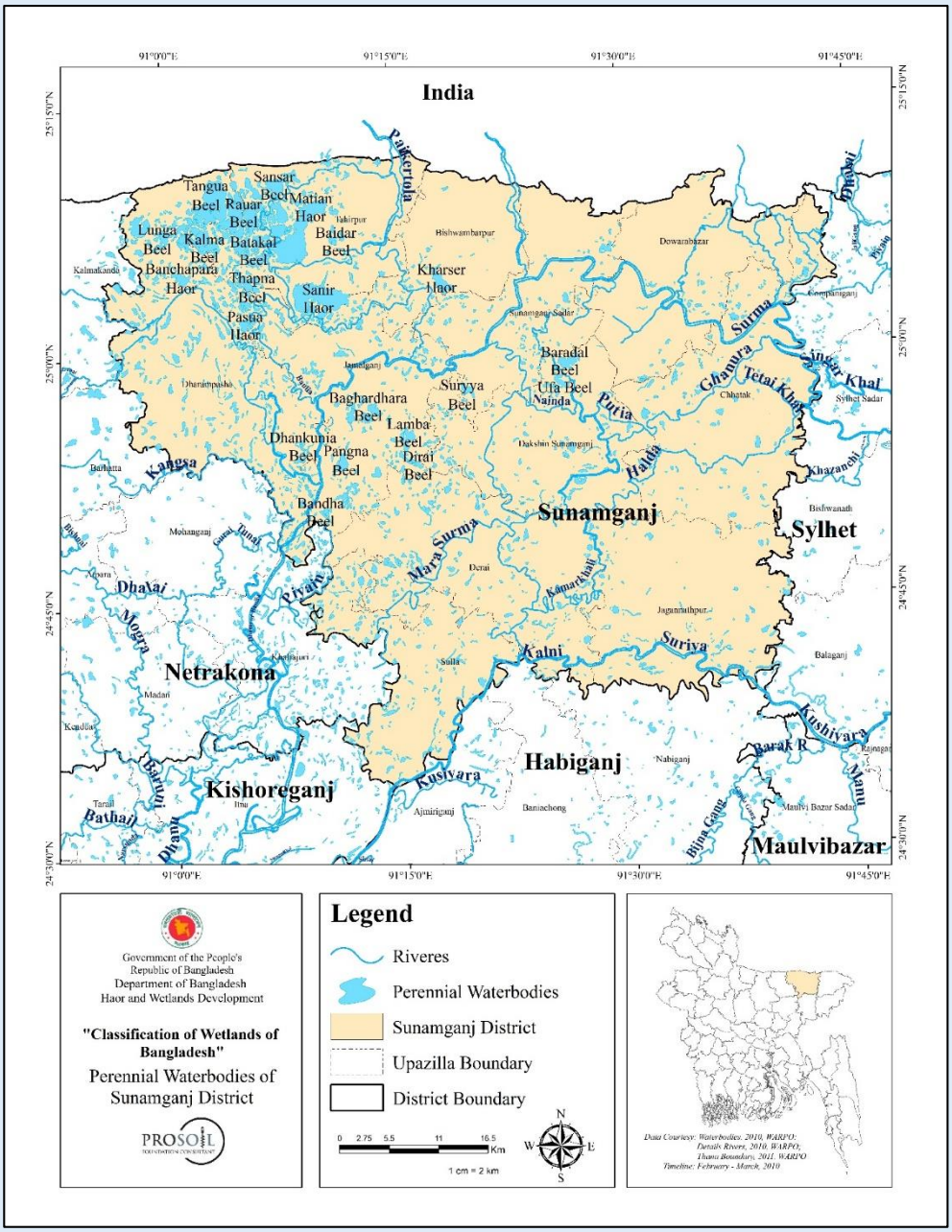
Box 6.7: A sample page of Annexure 9: Soil Information of Bangladesh

6.3.6 Haors

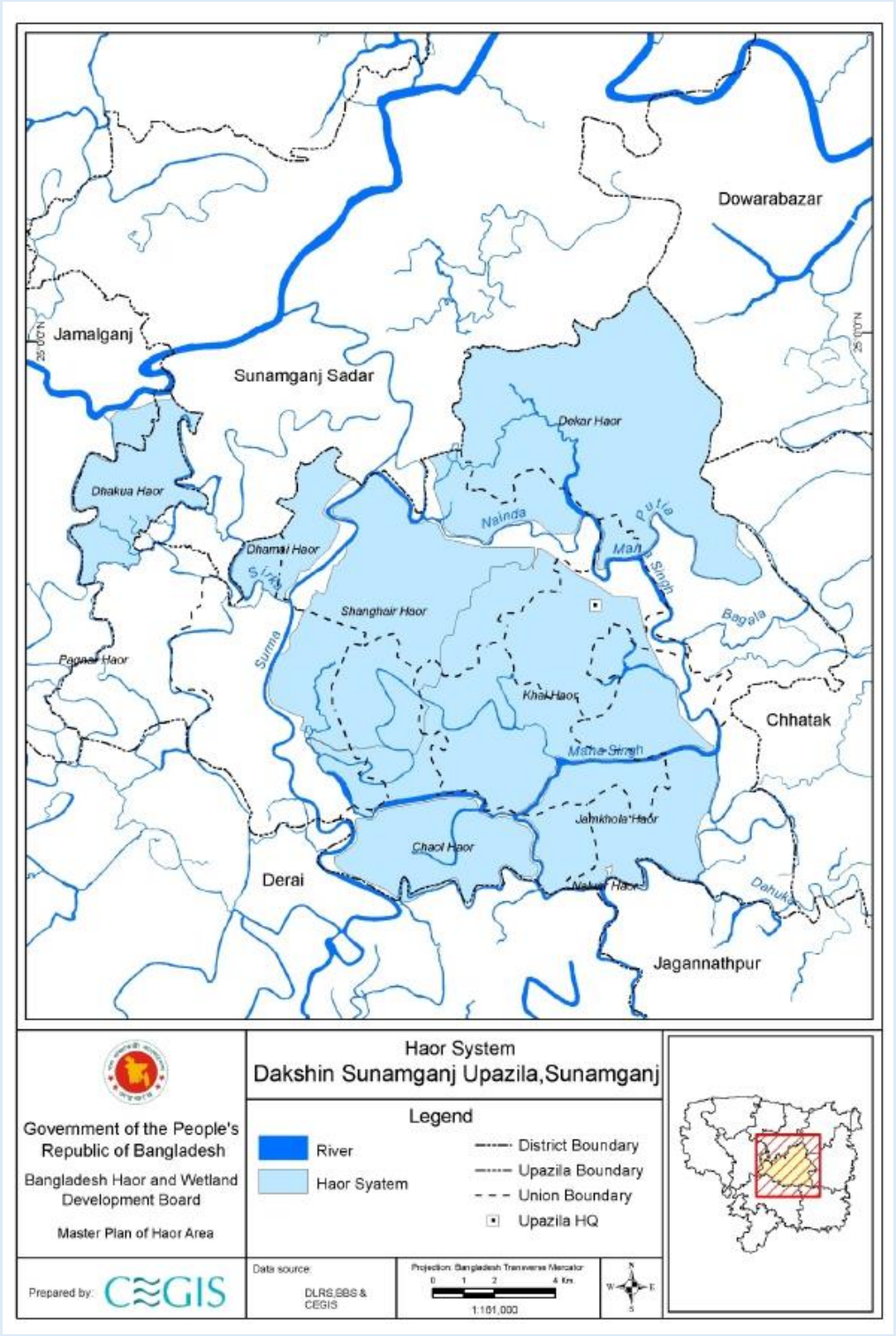
The data on haors of Bangladesh have been collected from Department of Bangladesh Haor and Wetland Development (DBHWD), Water Resources Planning Organization (WARPO) and Center for Environmental and Geographic Information Services (CEGIS). In the Master Plan of Haor Areas (2012), 373 haors have been identified in 49 upazillas of 7 haor districts (Sylhet, Sunamganj, Moulavibajar, Netrakona, Bramhanbaria, Kishoreganj and Habiganj). The data were compiled and **Annexure 2: Haors of Bangladesh** has been prepared. The attributes include name of the haor, area and location (upazilla, district). Maps of the haor districts and haor upazillas were also prepared. Sample pages from the Annexure 2 is shown in Boxes 6.8, 6.9 and 6.10.

Serial No.	Name of Haor	Serial No.	Name of Haor	Serial No.	Name of Haor
Haors of Sunamganj District					
1	Angurali	33	Hasharani Beel	65	Meda Beel
2	Arong Beel	34	Holdir	66	Medir Beel-1
3	Atla Beel	35	Huramondira	67	Morichapuri
4	Bahara	36	Jahidpur	68	Naidar
5	Bainchapra	37	Jaldhara/ Keuti	69	Naingoan
6	Balda Gulaghat	38	Jaliar	70	Naluar
7	Baram	39	Jamaikata	71	Naya Beel
8	Bedar Dohar	40	Jamkhola	72	Pagnar
9	Bhanda	41	Jaydhuna	73	Parua
10	Bhera Mohana	42	Joal Bhanga	74	Pingla
11	Chaliyar	43	Kachibanga	75	Rowail
12	Chaol	44	Kahilani- Sreekuli	76	Ruiyer Beel
13	Chaptir	45	Kainjar	77	Saidabad
14	Chawlar	46	Kalianibeel	78	Sakitpur
15	Chayer	47	Kalikota	79	Sangshar Beel
16	Chichrar	48	Kalnar	80	Saratir
17	Chilaura	49	Kalnikuri Beel	81	Sashkar
18	Choto Hijla- Baro Hijlar Beel	50	Kanir	82	Saytankhali Beel
19	Choukhali	51	Karchar	83	Shaldighar
20	Dekar	52	Katare Beel	84	Shanghair
21	Derai	53	Khai	85	Shanir
22	Dhakua	54	Kumuria Beel	86	Shimultala- Jalla
23	Dhamai	55	Kuri	87	Soilchapra
24	Dhankuniar	56	Kurshi Chak	88	Sonamorol
25	Dharam	57	Kuti Beel	89	Suktiar
26	Doyalong	58	Lepa	90	Sullal
27	Dubail	59	Lubar	91	Suraya Bibiyana
28	Gomrar	60	Lusni Beel	92	Tangua
29	Goradoba	61	Lusni Beel	93	Tanguar
30	Gurmar	62	Maddhanagar Boalar	94	Togar
31	Halir	63	Maheshpur	95	Udgal Beel
32	Harinagar	64	Matian		

Box 6.8: A sample page of Annexure 2: Haors of Bangladesh



Box 6.9: A sample map (Sunamganj district) of Annexure 2: Haors of Bangladesh



Box 6.10: A sample map (Dakshin Sunamganj upazilla) of Annexure 2: Haors of Bangladesh

6.3.7 Rivers

Four hundred and five (405) rivers have been identified by the Bangladesh Water Development Board (Bangladesh er Nod-Nodi, 2011). The data were compiled and **Annexure 1: Rivers of Bangladesh** was prepared. The rivers are classified as Perennial and Seasonal/Intermittent. The attributes include: Name of the River, Offtake, Outfall, Travel Path, Length, Width, Nature, Discharge, Distributaries, Tributaries, Branches and BWDB Stations.

A sample page from the Annexure 1 is shown in Box 6.11.

<table>
<tr><th colspan="6">ATRAI RIVER; BWDB Id: NW-2
Non-tidal, Perennial River</th></tr>
<tr><th>OFFTAKE</th><th>OUTFALL</th><th>TRAVEL PATH</th><th>DESCRIPTION</th><th>DISCHARGE</th><th>BWDB STATION</th></tr>
<tr><td>Hilly Area/ River/ Haor/ Baor/ Beel:
Karatoya River</td><td>River/ Haor/ Baor/ Beel/Sea:
Hura Sagor River</td><td rowspan="2">Dinajpur Sadar Upazila of Dinajpur District; Dhamoirhat, Patnitala, Mohadevpur, Manda, Atrai Upazila of Naogaon District;, Natore Sadar, Singra, Gurudaspur of Natore District; Chatmohar, Bhangura, Faridpur, Santhia Upazila of Pabna District; Shahjadpur Upazila of Sirajganj District</td><td>Length: 269 km</td><td rowspan="3">•Flow Less Months:
N/A

•Low Flow Months
(Dry Season): February-April;
Approx. flow: 3.59 cumec (April, SW 144-Chalkhariharpur)

•High Flow Months
(Monsoon Season): July-September;
Approx. flow: 3110 cumec (September, SW 144-Chalkhariharpur)

•River Bank Overflow Due to Normal Flood:
Yes</td><td rowspan="3">•Waterlevel: SW 143-Shamjhiaghat, 144-Chalkhariharpur 145-Mohadevpur, 146-Rasulpur, 147-Atrai Bridge, 147.5-Singra, 148-Chanchkair, 149-Astamanisha, 149.1-Gumani Bridge, 150-Dohakoladanga, 151-Baghabari (NTWL)

•Discharge: SW 144-Chalkhariharpur, 145-Mohadevpur, 147.5-Singra, 151-Baghabari (NTQ)

•Sediment Discharge:
N/A

•Salinity: N/A

•Water Quality: N/A

•Cross-Section: N/A</td></tr>
<tr><td>Location:
Dinajpur Sadar Upazila of Dinajpur District</td><td>Location:
Shahjadpur Upazila of Sirajganj District</td><td>Width:
Lowest: 127 m
Highest: 285 m
Average: 177 m</td></tr>
<tr><td>TRIBUTARY</td><td>DISTRIBUTARY</td><td>BRANCH</td><td rowspan="2">Nature:
Meandering;
Flood flow slope 5 cm/km</td></tr>
<tr><td>Gadai, Chiknai, Choto Jamuna, Barnai, Baral Upper (Baral-Nandakuja)</td><td>Fakirni, Shib</td><td>Shirmakhali Khal, Atrai (Naogaon-Natore), Baral Lower (Pabna), Besani</td></tr>
</table>

Box 6.11: A sample page of Annexure 1: Rivers of Bangladesh

6.3.8 Beels

The data on beels of Bangladesh have been collected from the Water Resources Planning Organization (WARPO). The data were compiled and **Annexure 4: Beels of Bangladesh** has been prepared. The beels have been arranged in 2 ways: Beels within haors and Beels of other floodplains. The attributes include name of the beel, location (upazilla, district, division) and area. It is reported that there are 6300 beels within the haor areas (FAP - 6). But from available data the team could prepare an incomplete list of beels within the haor area. Similarly, data of beels in floodplains are scanty. On the basis of available data and scanning of the satellite images, beels of flood plains have been identified. A sample page of from the Annexure 4 is shown in Box 6.12.

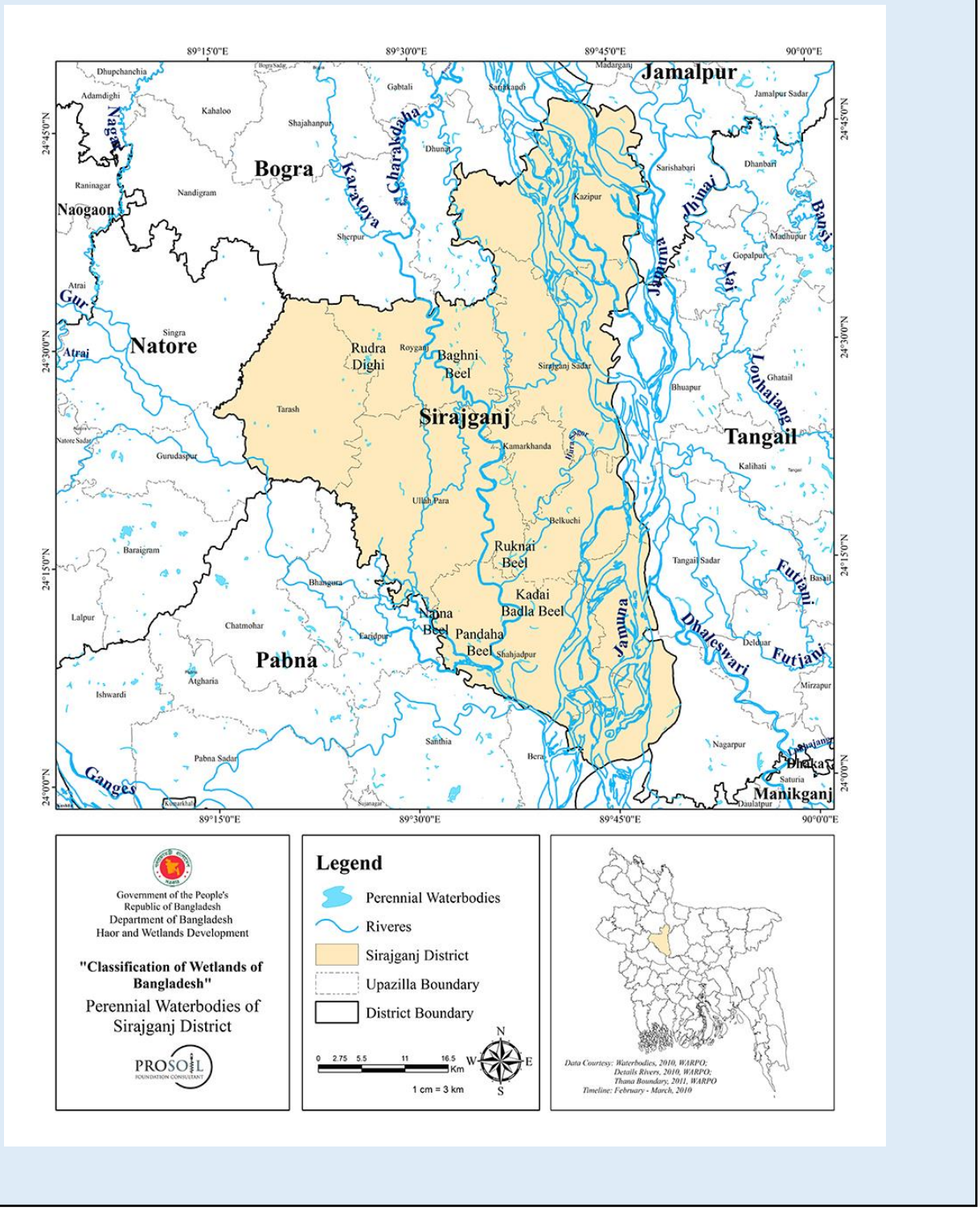
Sl. No	Name of Beel	Upazilla	District	Division	Area (HA)
1.	Pipuli Beel	Akhaura	Brahmanbaria	Chittagong	7.64
2.	Pipuli Beel	Akhaura	Brahmanbaria	Chittagong	9.43
3.	Bamadhar Beel	Bancharampur	Brahmanbaria	Chittagong	86.33
4.	Chandal Beel	Bancharampur	Brahmanbaria	Chittagong	61.60
5.	Galachipa Beel	Bancharampur	Brahmanbaria	Chittagong	1.75
6.	Kalla Beel	Brahmanbaria S.	Brahmanbaria	Chittagong	11.44
7.	Parenga Beel	Brahmanbaria S.	Brahmanbaria	Chittagong	5.14
8.	Raowa Beel	Brahmanbaria S.	Brahmanbaria	Chittagong	2.89
9.	Biajor Beel	Brahmanbaria S.	Brahmanbaria	Chittagong	1.59
10.	Sagardighi Beel	Brahmanbaria S.	Brahmanbaria	Chittagong	5.95
11.	Luchka Beel	Brahmanbaria S.	Brahmanbaria	Chittagong	0.85
12.	Langula Beel	Brahmanbaria S.	Brahmanbaria	Chittagong	3.32
13.	Halua Beel	Brahmanbaria S.	Brahmanbaria	Chittagong	2.10
14.	Puna Beel	Brahmanbaria S.	Brahmanbaria	Chittagong	9.73
15.	Barsala Beel	Brahmanbaria S.	Brahmanbaria	Chittagong	18.76
16.	Hatoni Beel	Kasba	Brahmanbaria	Chittagong	7.34
17.	Harkhal Beel	Nabinagar	Brahmanbaria	Chittagong	153.45

Box 6.12: A sample page from the Annexure 4: Beels of Bangladesh

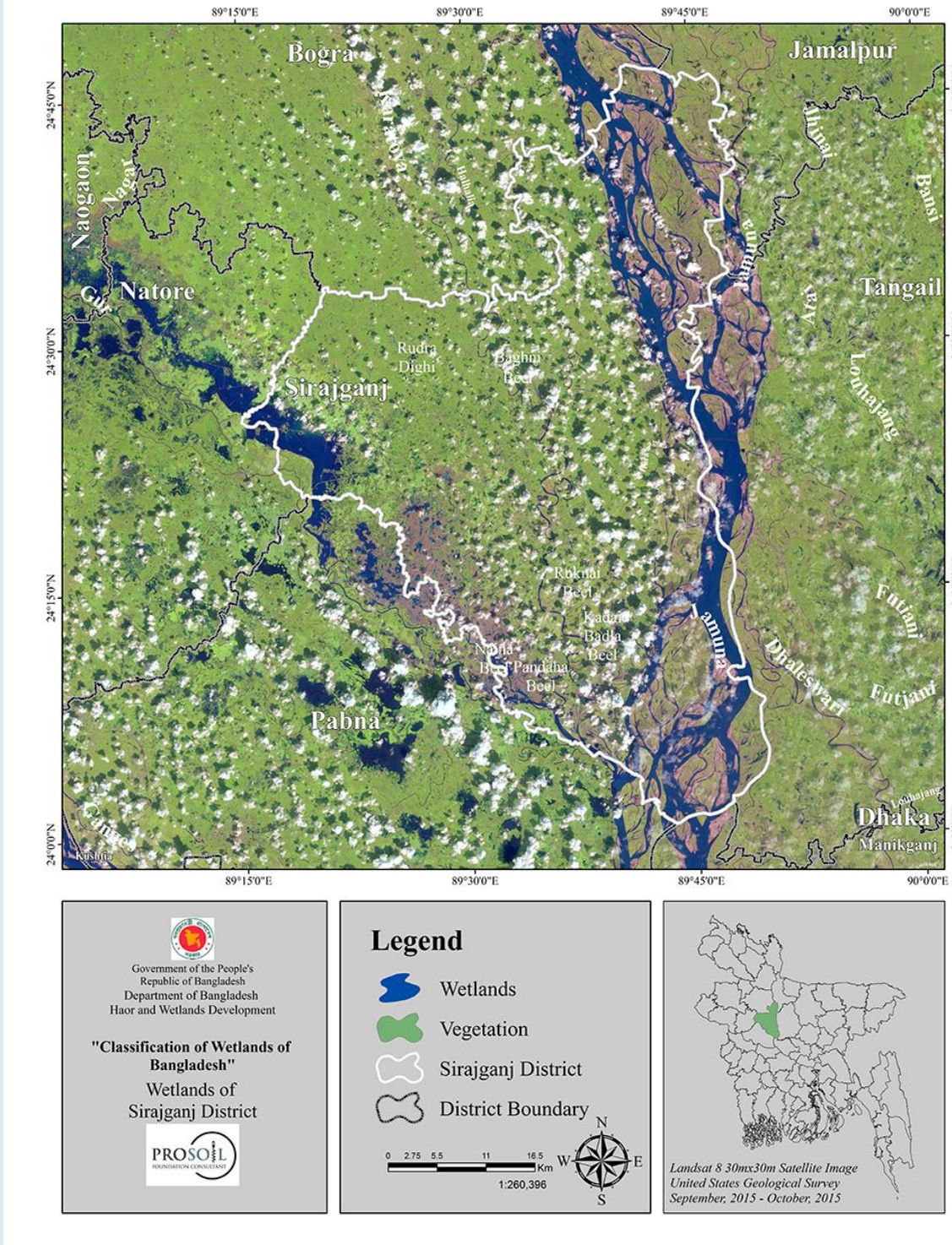
6.3.9 Perennial Waterbodies and Satellite Images

The data on perennial waterbodies have been collected from the Water Resources Planning Organization (WARPO). The data of the waterbodies include the following attributes: Name of the waterbodies and Area. Combining the data of perennial waterbodies with the administrative boundary of Bangladesh (also collected from WARPO), 64 separate district maps of perennial waterbodies have been prepared one for each district.

Satellite images have been collected from USGS (United States Geological Survey). The resolution is 30m x 30m. The time period is between September 2015 to October 2015. Super imposing the administrative boundaries on these satellite maps, 64 district maps of wetlands have been prepared, one for each district. These maps are included in the **Annexure 3: Maps of Wetlands of Bangladesh**. Two sample maps of Annexure 3 are shown in Boxes 6.13 and 6.14.



Box 6.13: A sample map of perennial waterbodies of Annexure 3: Maps of wetlands of Bangladesh



Box 6.14: A sample map of wetlands of Bangladesh of Annexure 3: Maps of wetlands of Bangladesh

6.3.10 Coastal Polders and FCD Projects

For identification of reversible wetlands, the data on coastal polders have been collected from the Bangladesh Water Development Board (BWDB). The data include the following attributes: name of Polder, location (Upazilla) and gross protected area. A total of 139 polders have been listed and presented in **Annexure 5: Reversible Wetlands**.

The data of coastal polders is important, because before construction of the polders, most of the areas within the polders were coastal wetlands. After the construction of the polders, they are flood free and no longer can be considered as wetlands. But these polders are vulnerable to tidal waves and storm surges. Every year there occur some breaches of coastal polders due to natural calamity (storm surges, cyclones etc) and/or poor maintenance. Once such breach occurs, the poldered area again turn into a wetland. Hence these coastal polders have been considered as vulnerable or reversible wetlands.

Flood control (FC), Drainage (D) and Flood Control and Drainage Projects (FCD) projects also transform wetlands to non-wetlands. These project areas are also vulnerable to natural calamities and/or poor maintenance. Hence, they are also classified as vulnerable or reversible wetlands.

The list of Reversible Wetlands is presented in **Annexure 5: Reversible Wetlands**. The list of Polders of Bangladesh has been presented in Annexure 5A and the list of Major FCD projects in Bangladesh has been presented in Annexure 5B. Sample pages of Annexure 5A and 5B are shown in Boxes 6.15 and 6.16 respectively.

Serial No.	Polder No./ Polder Name	Location (Name of Upazilla)	Gross Protected Area (HA)	District
1	1	Assasuni, Debhata & Satkhira	28381	Satkhira
2	2	Assasuni, Satkhira	11290	Satkhira
3	3	Debhata, Kaliganj	22267	Satkhira
4	4	Assasuni	10500	Satkhira
5	5	Kaliganj, Shymnagar	55061	Satkhira
6	6-8	Assasuni, Satkhira, Tala	18450	Satkhira
7	6-8 Ext.	Satkhira, Kalarua	8330	Satkhira
8	7/1	Assasuni,Shamnagar	3110	Satkhira
9	7/2	Assasuni	10486	Satkhira
10	9	Paikgacha	1255	Khulna
11	10-12	Koyara, Paikgacha	16315	Khulna
12	13-14/2	Koyara	17854	Khulna
13	14/1	Koyara	2933	Khulna
14	15	Shymnagar	3441	Khulna
15	16	Paikgacha, Tala (Satkhira)	10445	Khulna
16	17/1	Dumuria	5020	Khulna
17	17/2	Dumuria	3400	Khulna
18	18-19	Paikgacha	3380	Khulna
19	20,20/1	Paikgacha	1600	Khulna
20	21	Paikgacha	1417	Khulna
21	22	Paikgacha	1630	Khulna
22	23	Paikgacha	5910	Khulna
23	24	Abhaynagar, Dumuria (Khulna), Keshobpur, Manarampur	28340	Jessore

Box 6.15: A sample page of Annexure 5A: List of Polders of Bangladesh

	Name of the Project	Upazilla	District	Area (ha)	Starting Date	Completion date
1	Satla Bagda Scheme, Polder No.-1	Agailjhara	Barisal	14524	1972	1986
2	Paisarhat-Ramsil Project	Agailjhara	Barisal	7730	1986	1992
3	Satla Bagda Project Polder - 1 1&2	Agailjhara	Barisal	12229	1972	1986
4	Kakradhari Embankment Scheme	Babuganj	Barisal	3480	1992	1996
5	Padri Shibpur Scheme	Bakerganj	Barisal	1307	1990	1995
6	Bibichini Project	Bakerganj	Barisal	3114	1989	1994
7	Kakradhari Embankment Scheme	Banaripara	Barisal	3480	1992	1996
8	Satla Bagda Project Polder - 1 1&2	Banaripara	Barisal	12229	1972	1986
9	Kalkini Scheme South	Gaurnadi	Barisal	5008	1985	1993
10	Paisarhat-Ramsil Project	Gaurnadi	Barisal	7730	1986	1992
11	Hizla Embankment Scheme	Hizla	Barisal	3642	1974	1977
12	Hizla Embankment Scheme	Mehendiganj	Barisal	3642	1974	1977
13	POLDER 56/57 PROJECT (Inc BIP)	Mehendiganj	Barisal	119280	1963	1978
14	Kalkini Scheme South	Muladi	Barisal	5008	1985	1993
15	Kakradhari Embankment Scheme	Wazirpur	Barisal	3480	1992	1996
16	Satla Bagda Project Polder No.-3	Wazirpur	Barisal	1599	1987	1989
17	Satla Bagda Scheme,Polder No.-1	Wazirpur	Barisal	14524	1972	1986
18	Satla Bagda Project Polder - 1 1&2	Wazirpur	Barisal	12229	1972	1986

Box 6.16: A sample page from Annexure 5B: Reversible Wetlands (List of FCD Projects)

7 THE CLASSIFICATION SYSTEM

7.1 Strategy of Classification

In general, wetlands may be divided into estuarine and freshwater systems, which may be further subdivided by soil and plant type. Wetland area is characterized by sluggish or standing water that can create an open water habitat for wildlife *(Banglapedia, 2003)*. As mentioned earlier, there are generally recognized 5 major types of wetlands *(Ramsar, 1971)*. They are:

1. **Marine** (coastal wetlands including coastal lagoons, rocky shores, and coral reefs);
2. **Estuarine** (including deltas, tidal marshes, and mangrove swamps);
3. **Lacustrine** (wetlands associated with lakes);
4. **Riverine** (wetlands along rivers and streams); and
5. **Palustrine** (meaning "marshy"; marshes, swamps and bogs).

There is also a sixth type of wetland which has been recognized by Ramsar Classification which is **Human-made Wetlands** such as fish and shrimp ponds, farm ponds, irrigated agricultural land, salt pans, reservoirs, gravel pits, sewage farms and canals etc.

The Ramsar Classification System of wetlands includes 42 types of wetlands, grouped into three categories: Marine and Coastal Wetlands, Inland Wetlands, and Human-made Wetlands. The Ramsar classification system is given in Chapter 4, Table 4.1.

Based on the above mentioned 5 major types, Federal Geographic Data Committee(FGDC) of USA has developed 'Classification of Wetlands and Deepwater Habitats of the United States.' While preparing the classification system, the FGDC has given due consideration to the Ramsar classification system and Ramsar definition of wetlands. The FGDC classification system is hierarchical, progressing from System and Subsystems at the most general levels to Classes, Subclasses. This system categorizes all wetlands into 5 main systems. Every System is then divided into subsystems, and subsystems are divided into classes and classes are divided into subclasses. The FGDC classification system is given in Chapter 4, Table 4.1.

The Ramsar classification system essentially emphasizes on hydrology and then on plants (shrub and forest), but less on soil morphology or substrate. The plant composition, soil

morphology (condition and substrate) and hydrology (site wetness) are considered as the principal indicators of a wetland for ecological purpose, in the definition of FGDC.

The presence of water (site wetness) i.e. hydrology is central to the concept of wetland, and is often difficult to assess this indicator because of its dynamic (temporally variable) nature. Plant properties or soil properties (particularly of substrate) reflect the degree of prevailing wetness at a site over time. These two indicators show the habitat conditions.

The comparison between the two systems is presented below in a tabular form in table 7.1.

Table 7.1: Comparison Between Ramsar and FGDC Classification System

Ramsar	FGDC
Marine/ Costal Wetlands	**Marine System**
	Estuarine System
A -- Permanent shallow marine waters	-
B -- Marine Subtidal aquatic	Marine Subtidal Aquatic Bed
C -- Coral reefs	Marine Subtidal Reef, Marine intertidal Reef, Estuarine Subtidal Reef, Estuarine Intertidal Reef
D -- Rocky marine shores	Marine Intertidal Rocky Shore, Estuarine Intertidal Rocky Shore
E -- Sand, shingle or pebble shores	Marine Intertidal Unconsolidated Shore, Estuarine Intertidal Unconsolidated Shore
F -- Estuarine waters	Estuarine System
G -- Intertidal mud, sand or salt flats	-
H -- Intertidal marshes	Estuarine Intertidal Emergent Wetland
I -- Intertidal forested wetlands	Estuarine Intertidal Forested Wetland
J -- Coastal brackish/saline lagoons	-
K -- Coastal freshwater lagoons	-
Zk(a) – Karst and other subterranean hydrological systems	-
Inland Wetlands	**Riverine System**
	Lacustrine System
	Palustrine System
L -- Permanent inland deltas.	
M -- Permanent rivers/streams/creeks	Riverine System
N -- Seasonal/intermittent/irregular rivers/streams/creeks	Riverine System
O -- Permanent freshwater lakes	Lacustrine System
P -- Seasonal/intermittent freshwater lakes	Lacustrine System
Q -- Permanent saline/brackish/alkaline lakes.	-
R -- Seasonal/intermittent saline/brackish/alkaline lakes and flats.	-

Ramsar	FGDC
Sp-- Permanent saline/brackish/alkaline marshes/pools.	-
Ss-- Seasonal/intermittent saline/brackish/alkaline marshes/pools.	-
Tp-- Permanent freshwater marshes/pools	Palustrine System
Ts-- Seasonal/intermittent freshwater marshes/pools on inorganic soils	Palustrine System
U -- Non-forested peatlands	-
Va-- Alpine wetlands	-
Vt-- Tundra wetlands	-
W -- Shrub-dominated wetlands	Palustrine Scrub-Shrub Wetland
Xf-- Freshwater, tree-dominated wetlands	Palustrine Forested Wetlands
Xp-- Forested peatlands	Palustrine Forested Wetlands
Y -- Freshwater springs	-
Zg-- Geothermal wetlands	-
Human-made wetlands	**Special Modifiers**
1 -- Aquaculture (e.g., fish/shrimp) ponds	
2 -- Ponds	
3 -- Irrigated land	Farmed
4 -- Seasonally flooded agricultural land	Farmed
5 -- Salt exploitation sites	-
6 -- Water storage areas	Diked/Impounded
7 -- Excavations	Excavated
8 -- Wastewater treatment areas	Spoil
9 – Canal sand drainage channels, ditches	Partly Drained/Ditched
Zk(c) – Karst and other subterranean hydrological systems	-

In Bangladesh, traditionally the wetlands have been identified and given well defined names, such as rivers, haors, beels, lakes, ponds, dighis etc. The assessment of the habitat condition is time consuming due to lack of available data on plants and soil properties.

Both the rivers and floodplains of rivers are considered as wetlands. In Bangladesh, embankments and allied structures have been constructed both at inland and at coastal zone for flood control purposes. The area thus protected from flood by embankments or polders are not be considered as wetlands any more. However, there remains a great threat of breach or damage of the embankments due to natural hazards like cyclone or river erosion or due to other causes. If embankment breach occurs, the area will again be flooded regularly till repair

or construction of new embankment is made. This indicates that the area protected by the embankments or polders are vulnerable to become wetland again. Hence a terminology of '**Reversible Wetlands**' may be considered for these areas, which have been given flood protection and is vulnerable to become flooded if breach of embankment occurs or the embankments (flood control structures) are withdrawn. The FCD projects of BWDB and the coastal polders are examples of Reversible wetlands.

It may be mentioned that Vietnam and India have also developed their own classification system of wetlands considering their geographical location and condition, but broadly based on the Ramsar classification system. This strategy of development of country specific classification system of wetland considering own geographical and environmental situation yet based on the Ramsar classification framework appears to be appropriate for Bangladesh. Considering these, a strategy for classification of wetlands has been formulated and is given below.

The strategy of Classification of Wetlands of Bangladesh will be:

1. Ramsar definition of wetland will be followed.
2. The classification should be based on overall system of Ramsar classification of wetlands.
3. The classification will be based on the central issue of wetland concept i.e. hydrology.
4. Country specific classification system, considering geographical and environmental situation will be developed within the broad framework of Ramsar.
5. While Ramsar classification system has 3 broad types, Classification system of Bangladesh will have 4 types. One new type 'Reversible wetland' may be considered in classification of wetlands of Bangladesh.
6. The plant and soil data which will be collected during the study will be recorded and presented in the annexures.
7. Each system except the 'Reversible Wetlands' system is divided into two classes; Permanent and Non-permanent.

7.2 Classification of Wetlands of Bangladesh

As also mentioned earlier that, the Ramsar convention classifies the wetlands into three broad categories, namely Marine/Coastal wetlands, Inland Wetlands and Human made wetlands. In the context of Bangladesh, this wetland classification system is modified to better suit the unique characteristics of wetlands of Bangladesh. The wetlands of Bangladesh are primarily classified into four systems which are:

1. Marine/Coastal Wetlands
2. Inland Wetlands
3. Human-made Wetlands
4. Reversible Wetlands

Each system, except for Reversible wetlands is further classified into two classes, which are:

1. Permanent
2. Non-permanent

Each class is divided into different types and each type is designated with a unique name and symbol which corresponds to the similar type of Ramsar classification.

7.2.1 Marine/Coastal Wetlands:

Marine/Coastal wetlands are saltwater wetlands exposed to waves, currents and tides in an oceanic setting. Marine wetlands include sandy shores, estuarine lakes and lagoons, coastal floodplain forest, mudflats, coastal lakes, coastal floodplains, mangrove, saltmarsh swamps, coral reefs and aquatic subtidal beds with sea grass and kelps. Coastal and marine wetlands are important nursery and feeding areas for animals such as fish and marine turtles. There are 7 types of wetlands included under Marine/Coastal Wetlands system in the classification system of wetlands of Bangladesh.

BA: This type includes permanent shallow marine waters in the coastal zone and estuaries. In most cases, they are less than six meters deep during low tide. This type of wetland is mostly permanent in nature.

BB: This type includes marine subtidal aquatic beds, which includes kelp beds, sea-grass beds and tropical marine meadows. This type of wetland is mostly permanent.

BC: This type includes the coral reefs, which are permanent.

BE: This type includes sand, shingle or pebble shores. This type also includes sand bars, spits and sandy islets and sand dunes. This type is not a permanent wetland type.

BF: This type includes estuarine waters, estuaries and estuarine systems of deltas like char lands. This type is permanent.

BG: This type includes intertidal mud, sand or salt flats, which are not permanent wetlands.

BI: This type includes intertidal forested wetlands. It also includes mangrove swamps, nipah swamps and tidal freshwater swamp forests. This type is not permanent.

7.2.2 Inland Wetlands

Inland wetlands are diverse in characteristics and include rivers, floodplains, haors, baors, beels, jheels, khals and lakes. They are unevenly spread out over Bangladesh and most can be found in lowland plains. Inland wetlands are covered temporarily or permanently by fresh, brackish or saltwater. They provide a habitat for a number of plant and animal species such as birds, reptiles, amphibians and fish. During periods of dry season, many inland wetlands may stay dry for a long time. When heavier rainfall occurs, these wetlands fill up quickly again. There are 11 types of wetlands included under Inland Wetlands system in the classification system of wetlands of Bangladesh. They are:

BL: This type includes inland deltas and islands which are permanent.

BM: This type includes rivers, streams, creeks and waterfalls. These are permanent in nature.

BN: This type includes irregular rivers, creeks and streams. They are mostly seasonal, hence not permanent.

BO: This type includes the freshwater lakes which has an area over 8 ha. It includes large oxbow lakes which are permanent in nature.

BP: This type includes the freshwater lakes which has an area over 8 ha. It includes floodplain lakes which are not permanent.

BU: This type includes non-forested peatlands, shrub or open bogs, swamps and fens. These are not permanent wetlands.

BW: This type includes shrub-dominated wetlands; shrub swamps, shrub-dominated freshwater marshes, shrub carr and alder thicket on inorganic soils. These are not permanent wetlands.

BTp: This type includes freshwater marshes, pools and ponds with an area of less than 8 ha. It also includes marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season. This type of wetland is permanent.

BTs: This type includes seasonal freshwater marshes/pools on inorganic soils; includes sloughs, potholes, seasonally flooded meadows, sedge marshes**.** These are not permanent.

BXf: This type includes freshwater, tree-dominated wetlands, freshwater swamp forests, seasonally flooded forests and wooded swamps on inorganic soils. This type of wetland is not permanent.

BXp: This type includes forested peatlands and peat swamp forests, which is not permanent.

7.2.3 Human-made Wetlands:

Human-made wetlands are those that have not been purposely made to provide a habitat for plants and animals but to serve human needs such as storage of drinking water. Human-made wetlands are a way of cleaning up stormwater. These are designed to use appropriate plants to both help filter water as well as attract native animals. Human-made wetlands include saltworks, sewage treatment ponds, dams, irrigation projects, aquaculture ponds and reservoirs. The comparatively small size and unnatural water flows in this type of wetland does limit the ecological value. There are 9 types of wetlands included under Human-made Wetlands system in the classification system of wetlands of Bangladesh. They are:

B1: This type includes Aquaculture ponds for farming fish and shrimps. This is a permanent type of wetland.

B2: This type includes ponds with an area of less than 8 ha. Farm ponds, stock ponds and small tanks are included in this type. There wetlands are permanent in nature.

B3: This type includes irrigated lands, irrigation channels and rice fields. These are not permanent wetlands.

B4: This type includes seasonally flooded agricultural land , intensively managed or grazed wet meadow or pasture. These are not permanent wetlands.

B5: This type includes salt exploitation sites,salt pans, salines, saltworks etc. These are not permanent wetlands.

B6: This type includes water storage areas with an area over 8 ha. It also includes reservoirs, barrages, dams and impoundments. This type of wetland is permanent.

B7: This type includes excavations such as gravel, brick and clay pits; borrow pits and mining pools. These are not permanent.

B8: This type includes wastewater treatment areas, sewage farms, settling ponds, oxidation basins etc. These are permanent wetlands.

B9: This type includes canals, drainage channels and ditches. These are permanent wetlands.

7.2.4 Reversible Wetlands:

It was mentioned earlier that flood protected areas of lowland, inlands and coastal areas which are vulnerable to be flooded again due to overtopping, breach or withdrawal of embankments are the Reversible Wetlands. It also includes environmentally degraded but restorable wetlands. The FCD projects of BWDB and the coastal polders are examples of Reversible wetlands. There are 3 types of wetlands included under Reversible Wetlands system in the classification system of wetlands of Bangladesh. They are:

Brvc: This type includes all the coastal polders and embankments. A list of polders is given in Annexure 8.

Brvi: This type includes all FCD and FCDI projects and flood protected inlands which are protected by embankments.

Brve: This type includes environmentally degraded wetlands due to human intervention and can be restored to its original state.

7.2.5 Summary of Classification System of Bangladesh

The detailed classification system of wetlands of Bangladesh is summarized and provided in Table 7.2.

Table 7.2: Classification System of Wetlands of Bangladesh

Systems	Classes	Types Symbols	Name of wetland types
Marine/Coastal Wetlands	Permanent	BA	Permanent shallow marine waters in most cases less than six meters deep at low tide; includes sea bays and straits
		BB	Marine subtidal aquatic beds; includes kelp beds, sea-grass beds, tropical marine meadows
		BC	Coral Reefs
		BF	Estuarine waters; permanent water of estuaries and estuarine systems of deltas
	Non-Permanent	BE	Sand, shingle or pebble shores; includes sand bars, spits and sandy islets; includes dune
		BG	Intertidal mud, sand or salt flats
		BI	Intertidal forested wetlands; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests
Inland Wetlands	Permanent	BL	Permanent inland deltas
		BM	Permanent rivers/streams/creeks; includes waterfalls
		BO	Permanent freshwater lakes (over 8 ha); includes large oxbow lakes
		BTp	Permanent freshwater marshes/pools; ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season
	Non-Permanent	BN	Seasonal/intermittent/irregular rivers/streams/creeks
		BP	Seasonal/intermittent freshwater lakes (over 8 ha); includes floodplain lakes
		BTs	Seasonal/intermittent freshwater marshes/pools on inorganic soils; includes sloughs, potholes, seasonally flooded meadows, sedge marshes
		BU	Non-forested peatlands; includes shrub or open bogs, swamps, fens
		BW	Shrub-dominated wetlands; shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils
		BXf	Freshwater, tree-dominated wetlands; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils
		BXp	Forested peatlands; peatswamp forests

Systems	Classes	Types Symbols	Name of wetland types
Human-made Wetlands	Permanent	B1	Aquaculture (e.g., fish/shrimp) ponds
		B2	Ponds; includes farm ponds, stock ponds, small tanks; (generally below 8 ha)
		B6	Water storage areas; reservoirs/barrages/dams/impoundments (generally over 8 ha)
		B8	Wastewater treatment areas; sewage farms, settling ponds, oxidation basins, etc
		B9	Canals and drainage channels, ditches
	Non-Permanent	B3	Irrigated land; includes irrigation channels and rice fields
		B4	Seasonally flooded agricultural land (including intensively managed or grazed wet meadow or pasture)
		B5	Salt exploitation sites; salt pans, salines, etc
		B7	Excavations; gravel/brick/clay pits; borrow pits, mining pools
Reversible Wetlands		Brvc	Coastal polders and embankments
		Brvi	FCD and FCDI projects; flood protected inlands with embankments
		Brve	Environmentally degraded, but restorable wetlands

[Note 1:

***BX** – 'B' stands for Bangladesh, 'X' stands for corresponding X type of Ramsar wetland type*

Example:

***BA** – 'B' stands for Bangladesh, 'A' stands for Ramsar type (A: Permanent shallow marine waters in most cases less than six meters deep at low tide; includes sea bays and straits)*

***B1** – 'B' stands for Bangladesh, '1' stands for Ramsar type (1: Aquaculture (e.g., fish/shrimp) ponds)*

Note 2:

***Brvc** – 'B' stands for Bangladesh, 'rv' stands for Reversible Wetlands, 'c' stands for Coastal Polders and embankments.*

***Brvi** – 'B' stands for Bangladesh, 'rv' stands for Reversible Wetlands, 'i' stands for FCD and FCDI projects; flood protected inlands with embankments.*

***Brve** – 'B' stands for Bangladesh, 'rv' stands for Reversible Wetlands, 'e' stands for Environmentally degraded, but restorable wetlands.]*

7.3 Comparison between Classification Systems

7.3.1 Comparison between Classification of Wetlands of Bangladesh and Ramsar Classification System

It has been mentioned earlier that the classification system of wetlands of Bangladesh has been developed on the broad framework of Ramsar classification system of wetlands. As, Ramsar classification is a global system, it incorporates all types of characteristics of wetland existing all over the earth. Whereas, the classification system of Bangladesh is developed by specifically taking the characteristics of wetlands of Bangladesh into consideration. As also mentioned in Section 1.1 that there are some other types of wetlands included on the Ramsar system that do not exist in Bangladesh, such as Tundra wetlands, Alpine wetlands or Karst Topography.

The notation of each type in the classification system of Bangladesh corresponds to the same type of wetland in Ramsar classification system. For example, for the type BA – 'B' stands for Bangladesh, 'A' stands for Ramsar type (Permanent shallow marine waters in most cases less than six meters deep at low tide; includes sea bays and straits). The Ramsar system considered 3 systems of wetlands i.e., Marine and Coastal Wetlands, Inland Wetlands and Human-made Wetlands. But in Bangladesh wetlands classification system, a fourth system i.e. 'Reversible Wetlands' has been introduced. So, there are 4 systems in the Classification system of wetlands of Bangladesh. The comparison of the two systems is presented in Table 7.3 and Table 7.4.

Table 7.3: Summary of Comparison between Classification System of Bangladesh and Ramsar Classification System

	Classification System of Bangladesh	Ramsar Classification System
System	4	3
Classes	2 for each system except Reversible Wetlands	None
Types	30	42
Marine/Coastal Wetlands	7	12
Inland Wetlands	11	20
Human-made Wetlands	9	10
Reversible Wetlands	3	None

Table 7.4: Detailed Comparison between Classification System of Bangladesh and Ramsar Classification System

	Name of Classification Type	Ramsar Classification Symbols	Classification of Bangladesh Symbols
Marine/Coastal Wetlands	Permanent shallow marine waters in most cases less than six meters deep at low tide; includes sea bays and straits	A	BA
	Marine subtidal aquatic beds; includes kelp beds, sea-grass beds, tropical marine meadows	B	BB
	Coral reefs	C	BC
	Rocky marine shores; includes rocky offshore islands, sea cliffs	D	-
	Sand, shingle or pebble shores; includes sand bars, spits and sandy islets; includes dune	E	BE
	Estuarine waters; permanent water of estuaries and estuarine systems of deltas	F	BF
	Intertidal mud, sand or salt flats	G	BG
	Intertidal marshes; includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal brackish and freshwater marshes	H	-
	Intertidal forested wetlands; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests	I	BI
	Coastal brackish/saline lagoons; brackish to saline lagoons with at least one relatively narrow connection to the sea	J	-
	Coastal freshwater lagoons; includes freshwater delta lagoons	K	-
	Karst and other subterranean hydrological systems, marine/coastal	Zk(a)	-

Table 7.4: Detailed Comparison between Classification System of Bangladesh and Ramsar Classification System (continued)

	Name of Classification Type	Symbols	Classification of Bangladesh Symbols
Inland Wetlands	L -- Permanent inland deltas	L	BL
	M -- Permanent rivers/streams/creeks; includes waterfalls	M	BM
	N -- Seasonal/intermittent/irregular rivers/streams/creeks	N	BN
	O -- Permanent freshwater lakes (over 8 ha); includes large oxbow lakes	O	BO
	P -- Seasonal/intermittent freshwater lakes (over 8 ha); includes floodplain lakes	P	BP
	Q -- Permanent saline/brackish/alkaline lakes	Q	-
	R -- Seasonal/intermittent saline/brackish/alkaline lakes and flats	R	-
	Sp -- Permanent saline/brackish/alkaline marshes/pools	Sp	-
	Ss -- Seasonal/intermittent saline/brackish/alkaline marshes/pools	Ss	-
	Tp -- Permanent freshwater marshes/pools; ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season	Tp	BTP
	Ts -- Seasonal/intermittent freshwater marshes/pools on inorganic soils; includes sloughs, potholes, seasonally flooded meadows, sedge marshes	Ts	BTS
	U -- Non-forested peatlands; includes shrub or open bogs, swamps, fens	U	BU
	Va -- Alpine wetlands; includes alpine meadows, temporary waters from snowmelt	Va	-
	Vt -- Tundra wetlands; includes tundra pools, temporary waters from snowmelt	Vt	-
	W -- Shrub-dominated wetlands; shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils	W	BW
	Xf -- Freshwater, tree-dominated wetlands; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils	Xf	BXF
	Xp -- Forested peatlands; peatswamp forests	Xp	BXP
	Y -- Freshwater springs; oases	Y	-
	Zg -- Geothermal wetlands	Zg	-
	Zk(b) – Karst and other subterranean hydrological systems, inland	Zk(b)	-

Table 7.4: Detailed Comparison between Classification System of Bangladesh and Ramsar Classification System (continued)

	Name of Classification Type	Symbols	Classification of Bangladesh Symbols
Human-made Wetlands	1 -- Aquaculture (e.g., fish/shrimp) ponds	1	B1
	2 -- Ponds; includes farm ponds, stock ponds, small tanks; (generally below 8 ha)	2	B2
	3 -- Irrigated land; includes irrigation channels and rice fields	3	B3
	4 -- Seasonally flooded agricultural land (including intensively managed or grazed wet meadow or pasture)	4	B4
	5 -- Salt exploitation sites; salt pans, salines, etc	5	B5
	6 -- Water storage areas; reservoirs/barrages/dams/impoundments (generally over 8 ha)	6	B6
	7 -- Excavations; gravel/brick/clay pits; borrow pits, mining pools	7	B7
	8 -- Wastewater treatment areas; sewage farms, settling ponds, oxidation basins, etc	8	B8
	9 -- Canals and drainage channels, ditches	9	B9
Reversible Wetlands	Coastal polders and embankments	-	BRVC
	FCD and FCDI projects; flood protected inlands with embankments	-	BRVI
	Environmentally degraded, but restorable wetlands	-	BRVE

7.3.2 Comparison Between Classification of Wetlands of Bangladesh and FGDC Classification System

While developing the FGDC classification system, the FGDC committee of the USA considered the following standards:

- NOAA's (National) proposed *Coastal and Marine Ecological Classification Standard*
- FGDC endorsed the *National Vegetation Classification Standard* (Version 2). FGDC-STD-005-2008
- *National Hydrography Database* (NHD).
- 2009 FGDC *Wetlands Mapping Standard*;
- 2009 FWS bureau standard *Data Collection Requirements and Procedures for Mapping Wetland, Deepwater and Related Habitats of the United States*.
- *Content Standard for Digital Geospatial Metadata* (version 2.0);

- *Geospatial Positioning Accuracy Standards* Part 3;
- *National Standard for Spatial Data Accuracy*; and
- *Geographic Information Framework Data Content Standard, Part 5: Governmental unit and other geographic area boundaries*.

Both the FGDC classification system and Bangladesh classification system of wetlands considered the Ramsar classification system as a base of the classification system.

A comparison between Classification system of wetlands of Bangladesh and FGDC classification system is shown in Table 7.5.

Table 7.5: Comparison between Classification System of Wetlands of Bangladesh and FGDC Classification System

Classification System of Wetlands of Bangladesh			FGDC
Types	**System**	**Classes**	**System**
1. Marine/ Costal Wetlands			**Marine System**
			Estuarine System
BA	Permanent shallow marine waters in most cases less than six meters deep at low tide; includes sea bays and straits	Permanent	-
BB	Marine subtidal aquatic beds; includes kelp beds, sea-grass beds, tropical marine meadows	Permanent	Marine Subtidal Aquatic Bed
BC	Coral Reefs	Permanent	Marine Subtidal Reef, Marine intertidal Reef, Estuarine Subtidal Reef, Estuarine Intertidal Reef
BE	Sand, shingle or pebble shores; includes sand bars, spits and sandy islets; includes dune	Non-permanent	Marine Intertidal Unconsolidated Shore, Estuarine Intertidal Unconsolidated Shore
BF	Estuarine waters; permanent water of estuaries and estuarine systems of deltas	Permanent	Estuarine System
BG	Intertidal mud, sand or salt flats	Non-permanent	-
BI	Intertidal forested wetlands; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests	Non-permanent	Estuarine Intertidal Forested Wetland

Table 7.5: Comparison between Classification System of Wetlands of Bangladesh and FGDC Classification System (continued)

Classification System of Wetlands of Bangladesh			FGDC
Types	**System**	**Classes**	**System**
2. Inland Wetlands			**Riverine System**
			Lacustrine System
			Palustrine System
BL	Permanent inland deltas	Permanent	
BM	Permanent rivers/streams/creeks; includes waterfalls	Permanent	Riverine System
BN	Seasonal/intermittent/irregular rivers/streams/creeks	Non-permanent	Riverine System
BO	Permanent freshwater lakes (over 8 ha); includes large oxbow lakes	Permanent	Lacustrine System
BTP	Permanent freshwater marshes/pools; ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season	Permanent	Palustrine System
BTS	Seasonal/intermittent freshwater marshes/pools on inorganic soils; includes sloughs, potholes, seasonally flooded meadows, sedge marshes	Non-permanent	Palustrine System
BP	Seasonal/intermittent freshwater lakes (over 8 ha); includes floodplain lakes	Non-permanent	Lacustrine System
BU	Non-forested peatlands; includes shrub or open bogs, swamps, fens	Non-permanent	-
BW	Shrub-dominated wetlands; shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils	Non-permanent	Palustrine Scrub-Shrub Wetland
BXF	Freshwater, tree-dominated wetlands; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils	Non-permanent	Palustrine Forested Wetlands
BXP	Forested peatlands; peatswamp forests	Permanent	Palustrine Forested Wetlands

Table 7.5: Comparison between Classification System of Wetlands of Bangladesh and FGDC Classification System (continued)

Classification System of Wetlands of Bangladesh			FGDC
Types	**System**	**Classes**	**System**
3. Human-made wetlands			**Special Modifiers**
B1	Aquaculture (e.g., fish/shrimp) ponds	Permanent	-
B2	Ponds; includes farm ponds, stock ponds, small tanks; (generally below 8 ha)	Permanent	-
B3	Irrigated land; includes irrigation channels and rice fields	Non-permanent	Farmed
B4	Seasonally flooded agricultural land (including intensively managed or grazed wet meadow or pasture)	Non-permanent	Farmed
B5	Salt exploitation sites; salt pans, salines, etc	Non-permanent	-
B6	Water storage areas; reservoirs/barrages/dams/impoundments (generally over 8 ha)	Permanent	Diked/Impounded
B7	Excavations; gravel/brick/clay pits; borrow pits, mining pools	Non-permanent	Excavated
B8	Wastewater treatment areas; sewage farms, settling ponds, oxidation basins, etc	Permanent	Spoil
B9	Canals and drainage channels, ditches	Permanent	Partly Drained/Ditched
4. Reversible Wetlands			-
BRVC	Coastal polders and embankments	-	-
BRVI	FCD and FCDI projects; flood protected inlands with embankments	-	-
BRVE	Environmentally degraded, but restorable wetlands	-	-

Please note that the comparison has been made on consideration of broad types, however there could be some overlapping.

7.3.3 Relationship between Wetland Classification System and Land Classification System of Bangladesh

From agricultural point of view, soil scientists of Bangladesh adopt an approach to define land classes on the basis of depth and duration of inundation/flooding. The country has five land type (MPO, 1986) as shown in Table 7.6. This classification is based on the depth of water suitable for Aman cultivation.

Table 7.6: MPO Land Classification (1986)

Class	Inundation	Risk of Flooding
F0	Land inundation < 0.3m	Very Low Risk of Flooding
F1	Land inundated between 0.3m and 0.9m	Low Risk of Flooding
F2	Land inundated between 0.9m to 1.8m	High Risk of Flooding
F3	Land inundated more than 1.8m on which deepwater Aman can be grown.	Very High Risk of Flooding
F4	Land inundated more than 1.8m on which deepwater Aman cannot be grown.	Certainly Flooded

In this classification, the classes F1, F2, F3 and F4 can be considered as wetlands. Of the F0 class, some areas are also flooded up to a depth of 0.3 meter, and other areas are above normal flood level. The portion of F0 class which is inundated during normal flood can also be considered as wetlands.

Another classification of land types suggested by Brammer (2000) has 6 classes of land: Highland, Medium Highland, Medium Lowland, Lowland, Very Lowland and Bottomland. Table 7.7 shows this classification.

Table 7.7: Land Types According to Depth of Flooding

Land Type	Description
Highland (H)	Land which is above natural flood level
Medium Highland (MH) a. Medium Highland (MH 1) b. Medium Highland (MH2)	Land which is flooded up to about 90cm deep during monsoon season a. Land which is normally flooded up to 30cm depth. b. Land which is normally flooded up to 30-90cm depth.
Medium Lowland (ML)	Land which is normally flooded between 90cm to 180cm during the monsoon season.
Lowland (L)	Land Which is normally flooded up to between 180cm to 300cm during the monsoon season.
Very Lowland (VL)	Land which is normally flooded deeper than 300cm during the monsoon season.
Bottomland	Depression land in any of the above land types which remains wet throughout the year.

(Source: H. Brammer, 2000)

Among these land classes, medium highland (which remains flooded up to a depth of 90 cm during monsoon) through bottomland (which remains wet throughout the year) are considered as areas of wetlands, which corresponds to F0 (part), F1, F2, F3 and F4 types of land *(MPO Classification, 1986).*

8 EXAMPLES OF WETLANDS OF BANGLADESH

It has been mentioned earlier that the classification of wetlands of Bangladesh consists of four systems, namely:

1. Marine/Coastal Wetlands;
2. Inland Wetlands;
3. Human-made Wetlands and
4. Reversible Wetlands

It has two classes namely Permanent and Non-permanent and 30 types. Details of classification system of wetland of Bangladesh have been given in Chapter 7.

Some examples of different system and types of wetlands of Bangladesh are given in the following sections. Moreover, brief descriptions of some important wetlands have also been given.

Fig 8.1 shows the perennial waterbodies of Bangladesh.

Figure 8.1: Perennial Waterbodies of Bangladesh

8.1 Examples of Different Types of Wetlands in Bangladesh

Some general examples of different types of wetlands in Bangladesh is shown in Table 8.1.

Table 8.1: Examples of Wetland Types in Bangladesh

Systems	Classes	Types Symbols	Name of wetland types	Examples
Marine/Coastal Wetlands	Permanent	BA	Permanent shallow marine waters in most cases less than six meters deep at low tide; includes sea bays and straits	Entire coastal belt up to a depth of 6m
		BB	Marine subtidal aquatic beds; includes kelp beds, sea-grass beds, tropical marine meadows	Entire coastal belt and islands which remain inundated and where aquatic plants are grown
		BC	Coral Reefs	St. Martin's Island, some parts of Cox's Bazar
		BF	Estuarine waters; permanent water of estuaries and estuarine systems of deltas	Estuaries of Meghna and Karnaphuli, Shahbazpur Channel etc.
	Non-Permanent	BE	Sand, shingle or pebble shores; includes sand bars, spits and sandy islets; includes dune	Sea beaches of Bay of Bengal
		BG	Intertidal mud, sand or salt flats	Sea beaches of Teknaf, Cox's Bazar and other sea shores
		BI	Intertidal forested wetlands; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests	Sundarbans

Table 8.1: Examples of Wetland Types in Bangladesh (contd.)

Systems	Classes	Types Symbols	Name of wetland types	Examples
Inland Wetlands	Permanent	BL	Permanent inland deltas	Char lands of rivers
		BM	Permanent rivers/streams/creeks; includes waterfalls	Permanent rivers of Bangladesh, waterfalls etc.
		BO	Permanent freshwater lakes (over 8 ha); includes large oxbow lakes	Beels, Baors
		BTp	Permanent freshwater marshes/pools; ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season	Beels within haor areas
Inland Wetlands	Non-Permanent	BN	Seasonal/intermittent/irregular rivers/streams/creeks	Seasonal rivers of Bangladesh, hilly streams, springs etc.
		BP	Seasonal/intermittent freshwater lakes (over 8 ha); includes floodplain lakes	Haors, Beels
		BTs	Seasonal/intermittent freshwater marshes/pools on inorganic soils; includes sloughs, potholes, seasonally flooded meadows, sedge marshes	Lowland, potholes etc. within haor area
		BU	Non-forested peatlands; includes shrub or open bogs, swamps, fens	Peatlands within haor areas, beels of Satkhira, Khulna & Gopalganj
		BW	Shrub-dominated wetlands; shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils	Seen within haor area
		BXf	Freshwater, tree-dominated wetlands; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils	Seen within haor area
		BXp	Forested peatlands; peatswamp forests	Forested peatlands of lowlands of Satkhira, Khulna & Gopalganj

Table 8.1: Examples of Wetland Types in Bangladesh (contd.)

Systems	Classes	Types Symbols	Name of wetland types	Examples
Human-made Wetlands	Permanent	B1	Aquaculture (e.g., fish/shrimp) ponds	Dighi, ponds, shrimp ponds
		B2	Ponds; includes farm ponds, stock ponds, small tanks; (generally below 8 ha)	Small ponds, including ponds for fish culture
		B6	Water storage areas; reservoirs/barrages/dams/impoundments (generally over 8 ha)	Reservoir of Teesta & Kaptai, Dams of Muhuri & reservoirs of Magura etc.
		B8	Wastewater treatment areas; sewage farms, settling ponds, oxidation basins, etc	WWTP of Pagla (Dhaka WASA)
		B9	Canals and drainage channels, ditches	Madaripur Beel Route, Mongla-Ghashikhali Channel, Gab Khan Channel, Irrigation channels of BWDB, Teesta Irrigation Project
	Non-Permanent	B3	Irrigated land; includes irrigation channels and rice fields	Irrigation project areas of the BWDB
		B4	Seasonally flooded agricultural land (including intensively managed or grazed wet meadow or pasture)	Floodplains of the rivers
		B5	Salt exploitation sites; salt pans, salines, etc	Salt areas and salt cultivation areas of Teknaf and Barisal
		B7	Excavations; gravel/brick/clay pits; borrow pits, mining pools	Roadside borrow pits, Barapukuria Coal Mine etc.
Reversible Wetlands		Brvc	Coastal polders and embankments	139 coastal polders of the country
		Brvi	FCD and FCDI projects; flood protected inlands with embankments	All inland BWDB FCD & FCDI projects
		Brve	Environmentally degraded, but restorable wetlands	Polluted rivers, encroached rivers, khals, lowlands etc.

8.2 Marine/Coastal Wetlands

A brief description of one of the Marine/Coastal wetlands is given below:

Sundarbans (BI type): The Sundarbans is a natural region comprising southern Bangladesh and a small part in the Indian state of West Bengal. It is the largest single block of tidal halophytic mangrove forest in the world. The Sundarbans covers approximately 10,000 square kilometers (3,900 sq. mi) most of which is in Bangladesh with the remainder in India. The Sundarbans has been declared a UNESCO World Heritage Site in 1997 *(World Heritage Convention, 1997)*. The Sundarbans has also been declared as a Ramsar site *(Ramsar, 1992)*. The Sundarban forest lies in the vast delta on the Bay of Bengal formed by the super confluence of the Ganges, Padma, Brahmaputra and Meghna rivers across southern Bangladesh. The seasonally flooded Sundarban's freshwater swamp forests lie inland from the mangrove forests on the coastal fringe. The Sundarbans is intersected by a complex network of tidal waterways, mudflats and small islands of salt-tolerant mangrove forests. The interconnected network of waterways makes almost every corner of the forest accessible by boat.

A total 245 genera and 334 plant species have been recorded *(D. Prain, 1903)*. While most of the mangroves in other parts of the world are characterized by members of the Rhizophoraceae, Avicenneaceae or Combretaceae, the mangroves of Bangladesh are dominated by the Malvaceae and Euphorbiaceae. The Sundarbans flora is characterized by the abundance of sundari (*Heritiera fomes*), gewa (*Excoecaria agallocha*), goran (*Ceriops decandra*) and keora (*Sonneratia apetala*) all of which occur prominently throughout the area *(Hussain & Acharya, 1994)*.

A 1991 study has revealed that the Bangladeshi part of the Sundarbans supports diverse biological resources including at least 150 species of commercially important fish, 270 species of birds, 42 species of mammals, 35 reptiles and 8 amphibian species. This represents a significant proportion of the species present in Bangladesh (i.e. about 30% of the reptiles, 37% the birds and 34% of the mammals) and includes many species which are now extinct elsewhere in the country *(Scott, 1991)*.

The list of plants of Sundarbans mangrove forest has been presented in the **Annexure 6B: Plants of Sundarbans Mangrove Forest**.

Figure 8.2: Landsat 7 image of Sundarbans, released by NASA Earth Observatory

8.3 Inland Wetlands

Inland wetlands include rivers, haors, baors, beels, jheels, khals, natural lakes, ponds, dighis etc. Brief description of some of the important inland wetlands are given below.

8.3.1 Rivers (BM & BN types)

The rivers of Bangladesh mark both the physiography of the nation and the life of the people. About 405 in number, these rivers generally flow south. The larger rivers serve as the principal arteries of commercial transportation and main source of water for cultivation. Rivers also provide fish, an important source of protein. List of the rivers are given in **Annexure 1: Rivers of Bangladesh**. Perennial rivers are of BM type and Seasonal/Intermittent rivers are of BN type.

There are 4 main river systems in Bangladesh. They are:

1. Brahmaputra-Jamuna River System
2. Ganges-Padma River System
3. Surma-Meghna River System
4. Chittagong Region River System

Brief description of the 4 major river systems has been given in section 3.2.1.1 and Appendix A.

8.3.2 Beels (BP, BO & BTp types)

Beels have been arranged in the following 2 ways:

1. Beels of the floodplains (BO, BP)
2. Beels of Haor areas (BP, BTp)

List of the beels has been presented in the **Annexure 4: Beels of Bangladesh**. A brief description of a floodplain beel named Chalan Beel is given below.

Chalan Beel (BO): Chalan Beel is an extensive lowland area in the lower Atrai basin, and spreads across Singra and Gurudaspur upazilas of Natore, Chatmohar, Bhangura and Faridpur upazilas of Pabna District, and Ullahpara, Raiganj and Tarash upazilas of Sirajganj districts. The major parts of it cover an extensive area of Raiganj upazila of Sirajganj district and Chatmohar upazila of Pabna district. It consists of a series of beels connected to one another by various channels to form a continuous water body during the rainy season. Chalan beel was formed when the old Brahmaputra diverted its water into the new channel of the Jamuna. Chalan beel was probably a backswamp before it was greatly expanded with the inclusion of abandoned courses of the Karatoya and the Atrai and became a vast lake. The formation of the Chalan beel is historically linked with the demise of the Atrai and the Baral. The Atrai or the Gur was the principal feeder channel of Chalan beel, which used to drain the districts of Dinajpur and northern Rajshahi. The Baral works as an outlet of the beel and eventually finds its way into the Jamuna. It was about 1,088 sq. km in area at the time it was formed *(Banglapedia, 2003).*

The southern edge of the beel is skirted by the Gumani, which carries the water of the beel into Bara beel, which in turn carries the water into the Jamuna. During the rainy season the Gumani overflows its banks and pours its water into the beel. When the Jamuna is flooded, the water of the Baral is held up until the Jamuna falls again. During the dry season, the greater part of the beel dries up, leaving a water basin of about 25.9 to 31.08 sq. km, which may be called its 'core'. However, the core is not covered with an uninterrupted expanse of water. It remains a collection of shallow sheets of water connected with each other by very tortuous channels. Round the core, there are two concentric irregular shaped oval areas

growing rice of the long-stemmed variety, usually known as floating rice. The first 'ring', rather narrow towards the southwest, is covered with 1.53 to 1.83m of water during the rainy season. The west of Chalan beel may be included in the 'outer ring', where water in the rainy season is much less than other parts of the beel. Both the rings dry up entirely between December and June.

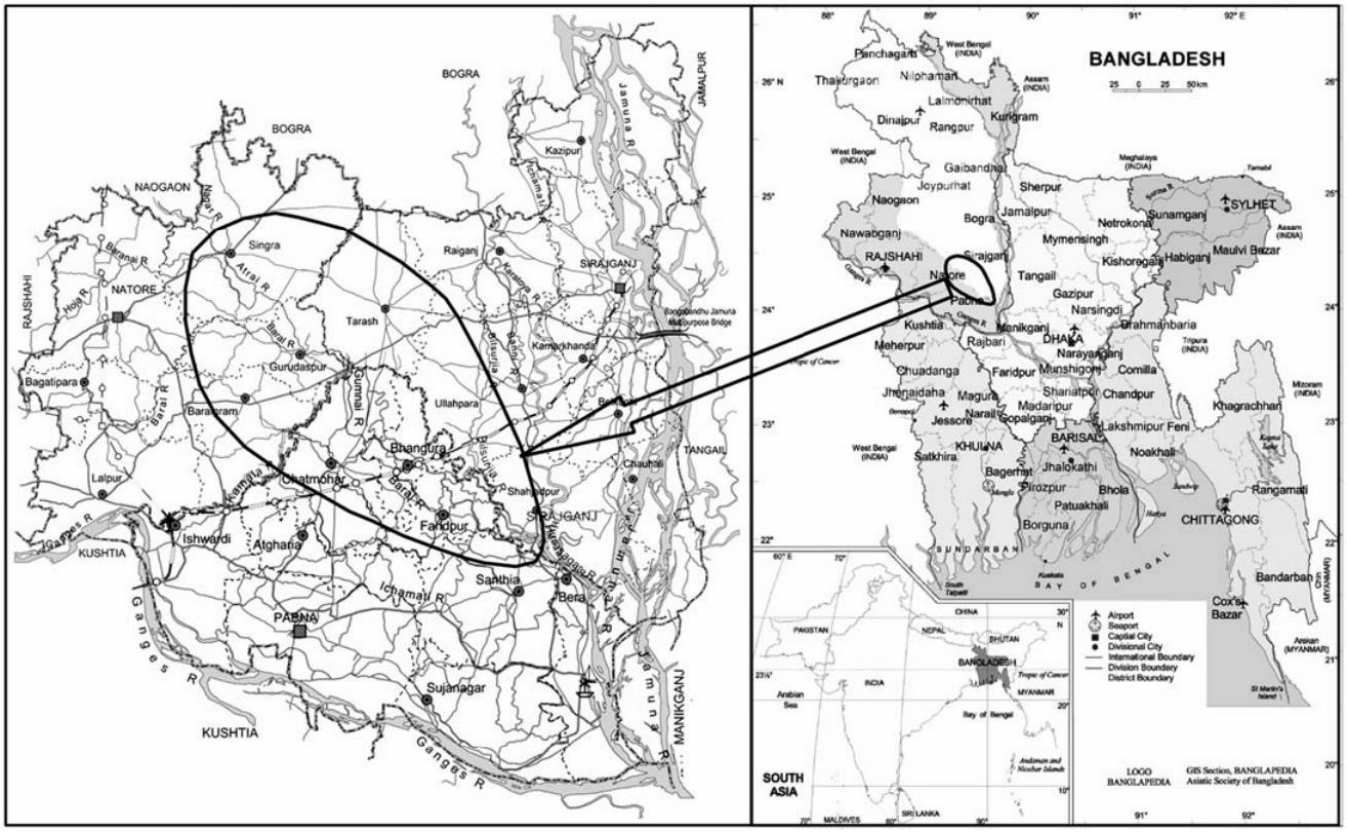


Figure 8.3: Location of Chalan Beel (Source: Banglapedia, 2003)

8.3.3 Haors (BP, BTp & BTs types)

Haors are important wetlands of the country. A list of Haors has been prepared and presented in the **Annexure 2: Haors of Bangladesh**. Two most important haors, namely Tanguar Haor and Hakaluki Haor have been declared as Ramsar Site. Brief description of the Tanguar Haor and Hakaluki Haor are given below:

Tanguar Haor (BP & BTp types): Tanguar Haor is located in two Upazillas (sub-districts) namely Tahirpur and Dharmapasha of Sunamganj district in Sylhet Division. The Tanguar Haor basin, which is an area of 10,000 hectares of land, also supports about 60,000

populations with its resources. Tanguar haor is a natural freshwater wetland in the country, seasonally harboring up to 60,000 migratory waterfowl along with many resident birds, more than 140 fish species and last vestiges of swamp forest. It is recognized as a Ramsar site. It is estimated that a total of 200 wetland plant species, 141 fish species, 11 amphibians, 34 reptiles (6 turtles, 7 lizards and 21 snakes), 206 birds and 31 mammals occur in this haor (Gieson and Rashid, 1997). Principle wetland habitats of Tanguar Haor include open water (with submerged and floating aquatic vegetation), seasonally inundated mixed herbaceous vegetation, reed beds and rice fields *[Nishat (1993), Karim (1993), NERP (1993a) and BNH (1997)]*.

List of plants, birds and animals of Tanguar Haor have been presented in **Annexure 6C: Plants of Tanguar Haor**, **Annexure 6D: Birds of Tanguar Haor** and **Annexure 6E: Animals of Tanguar Haor**.

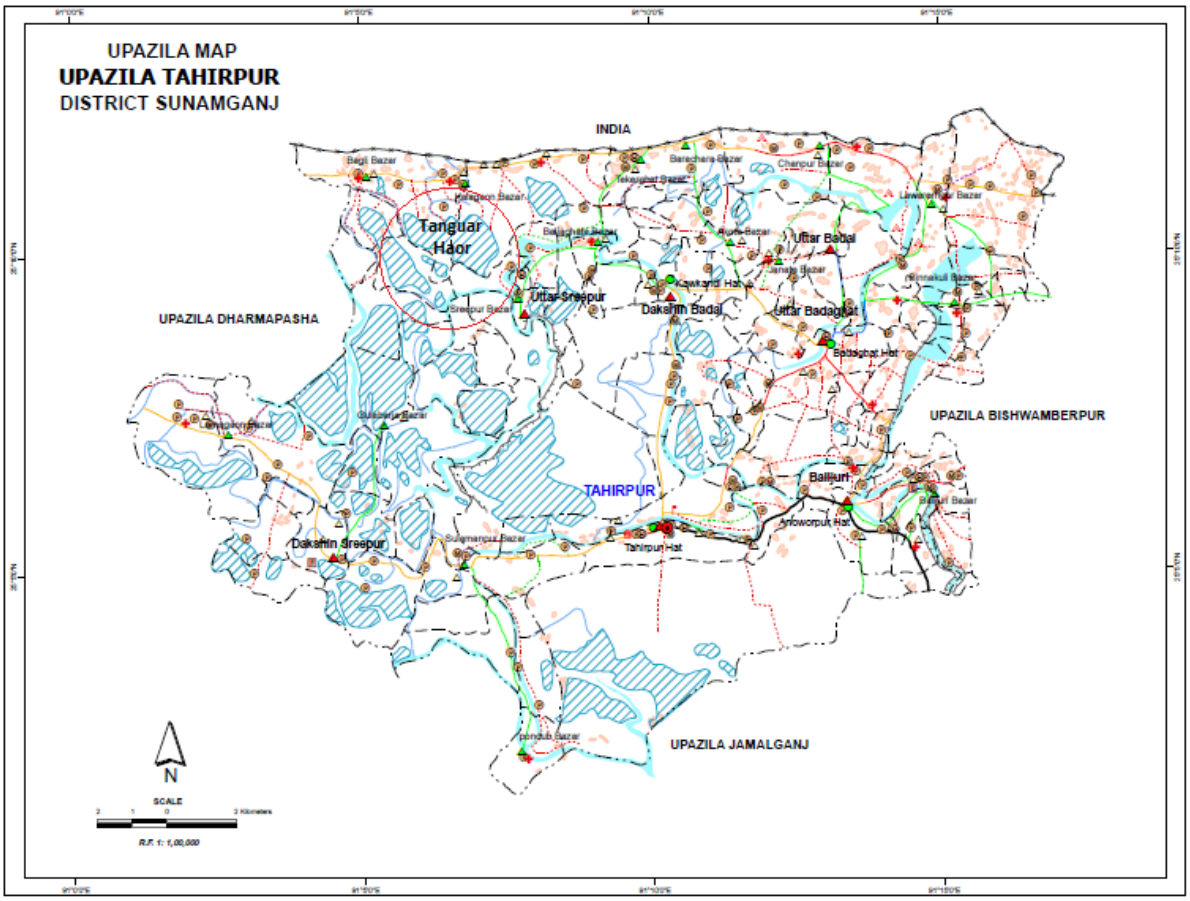


Figure 8.4: Location of Tanguar Haor (Source: LGED, 2010)

Figure 8.5: Tanguar Haor

Hakaluki Haor: Hakaluki Haor is situated in the eastern part of Bangladesh adjacent to the Assam-Bangladesh border. 5 upzillas comprise this haor's total area (Kulaura, Juri and Baralekha of Moulvibazar district, Golapganj and Fenchuganj of Sylhet district). It covers a large surface area of about 181.15 km2. Around 40% of this land falls in the territory of Baralekha upzilla. There are more than 238 small, medium and large interconnecting beels, some of which are perennial and others seasonal. During the dry season, approximately 4,4000 ha are being covered by the beel, but with the onset of the rains in the summer, the entire area floods to about four and half times of this size (18,383 ha) and remains under water for up to five months. During this period, all the beels are united as one large lake, or haor, making Hakaluki Haor the largest freshwater wetland in Bangladesh. The haor is mainly fed by the Juri/ Kantinala, Sonai/ Bordol, Damai. Fanai, and Kuiachara Rivers, out of which the Bordol/ Sonai, and Juuri/ Kantinala Rivers are originated in India *(Banglapedia, 2003).*

A total of 558 species of animal and birds have been identified here. Among these are the freshwater Turtle and Tortoises, Otters, Capped Langur, Pallas's Fish Eagle, dolphin, snakes etc. 417 species of birds have been spotted here among which 26 are totally threatened, 2 are vulnerable, and 10 are endangered and 14 critically endangered species *(Banglapedia, 2003).*

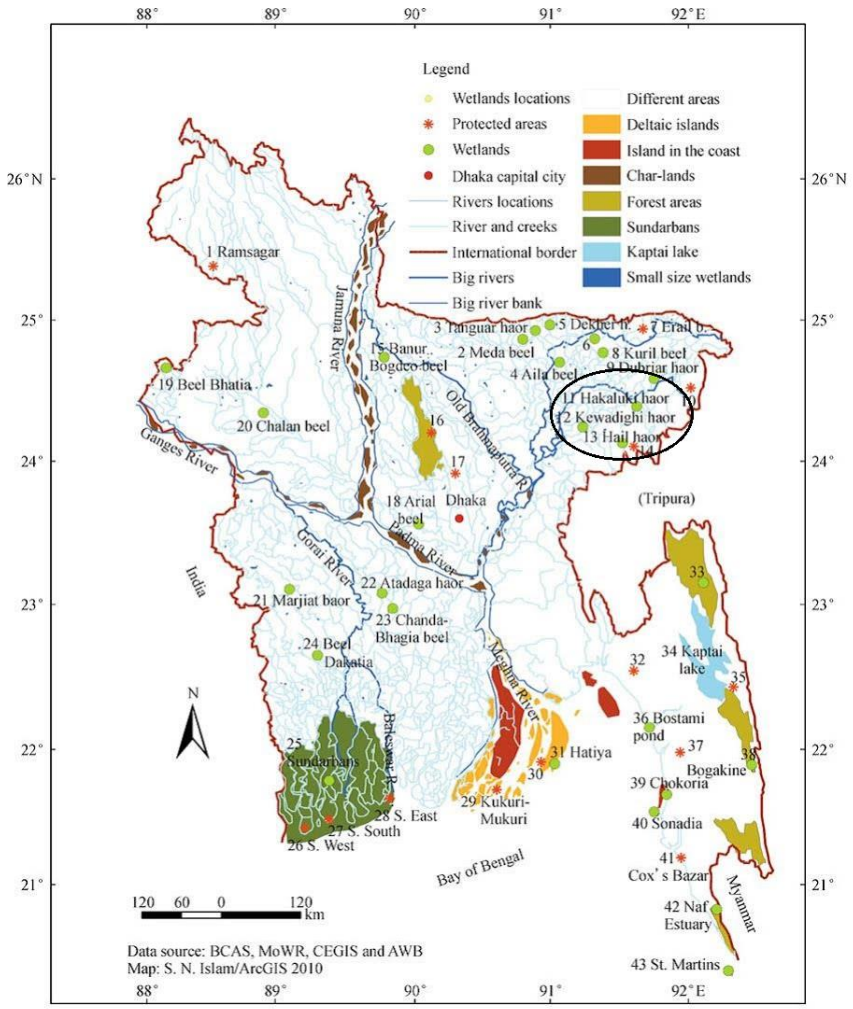


Figure 8.6: Location of Hakaluki Haor (Source: Islam, 2010)

Figure 8.7: Hakaluki Haor

8.3.4 Natural Lakes (BO type)

Natural lakes are considered to be of BO type of wetland. Bangladesh does not have much natural lakes. However, brief description of 2 natural lakes are given below.

Boga Lake (BO type): Bogakain Lake, also called Baga Lake or Boga Lake, is a lake located in Ruma Upazila in the hill district Bandarban, Bangladesh. It is a natural sweet and deep water lake. Its height from sea level is nearly 2,000 feet (610 m). Geologists believe that it was created by collection of rain water in the crater of a dead volcano almost 2000 years ago. The lake is almost rectangular in shape. The lake is bounded on three sides by mountain peaks covered with thick bamboo bushes. The area of the lake is 18.56 acres (75,100 m^2) *(Rahman & Karim, 2012)*. It is a closed lake and there is a small spring named Boga chhara, which is 153 meters (502 ft) deep. There is no outlet for draining out water from the lake. The lake is composed of the soft rocks of the Bhuban Formation. The main source of water is the spring and rainfall. The water is crystal clear and under the lake the water there are rocks and boulders all over.

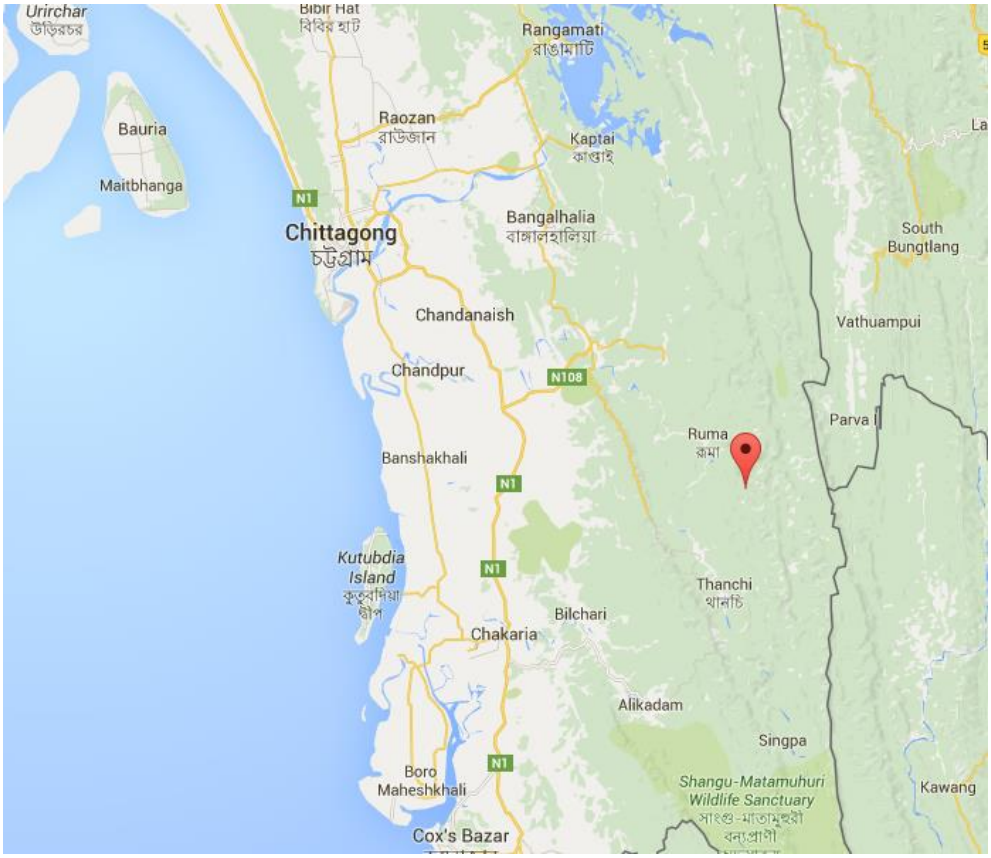


Figure 8.8: Location of Boga Lake (Source: Google Maps)

Figure 8.9: Boga Lake

Madhabpur Lake (BO type): Madhabpur Lake is a lake of Srimangal in Maulvi Bazar District of Bangladesh. It is a natural lake inside the Madhabpur tea estate. It is one of the popular tourist spot in Bangladesh. It is home to the Great White-Bellied Heron, the only confirmed site in Bangladesh.

Figure 8.10: Madhabpur Lake

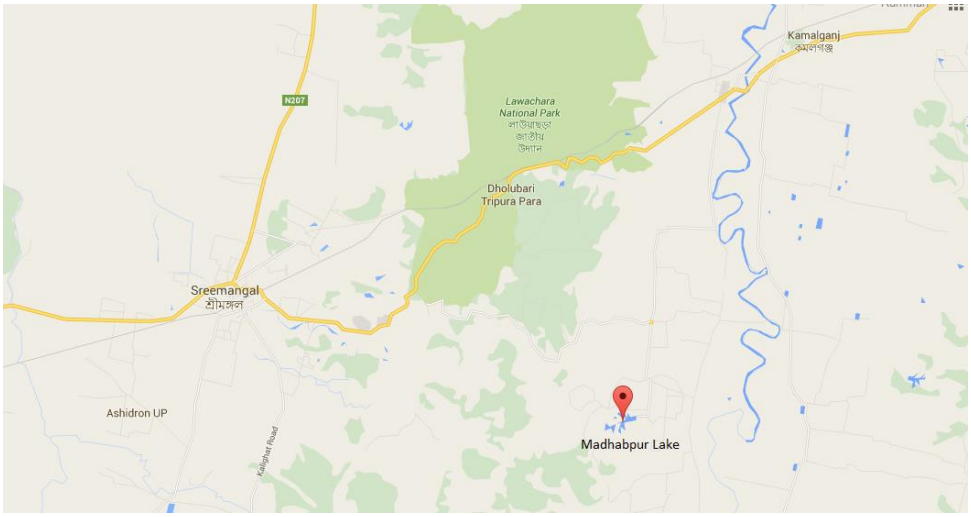


Figure 8.11: Location of Madhabpur Lake (Source: Google Maps)

8.4 Human-made Wetlands

A brief description of a human made wetland, the Kaptai Lake is given below.

Kaptai Lake (B6 type): Kaptai Lake is the largest man-made lake in Bangladesh and is considered as a B6 type of wetland. It is located in the Kaptai Upazila under Rangamati district of Chittagong Division. The lake was created as a result of construction of the Kaptai Dam on the Karnaphuli River, as part of the Karnaphuli Hydro-Electric Project. The Kaptai Lake's average depth is 30m (100 ft) and maximum depth is 150m (490 ft). Construction of the reservoir for the Hydro-Electric Plant began in 1956 by the Government of the then East Pakistan (now Bangladesh). As a result, about 220 km^2 of farmland in the Rangamati District went under water and created the lake. The hydro-electric project was funded by the United States. The project was finished in 1962. The dam is 670.8 meters long, and 54.7 meters high. The dam has a 227m (745 feet) long spillway containing 16 gates. Through the spillway 149,000 m3/s (5,250,000 cu ft/s) of water can pass. The land that went under water as a result of the dam construction, was 40% of the total arable land in the area. Along with that, 75 km^2 (29 square miles) of the Government-owned forest, and 610 km^2 (234 square miles) of other forest land went under water. About 18,000 families with a total of almost 100 thousand people were also displaced. The palace of the king of the Chakmas was also flooded and is now under water.

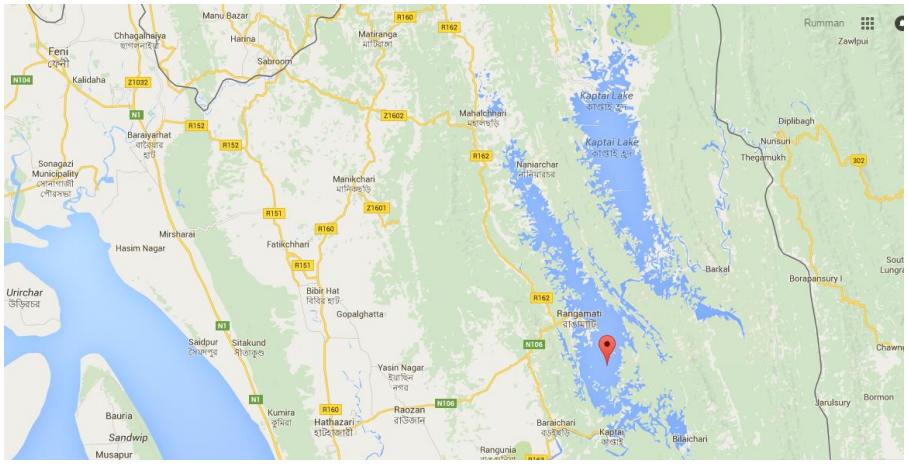


Figure 8.12: Location of Kaptai Lake (Source: Google Maps)

Figure 8.13: Kaptai Lake

8.5 Reversible Wetlands

It has been also mentioned in Section 7.1 that Reversible wetlands are the lands which were considered wetlands, but turned into agricultural or habitable lands by constructing embankments, polders and allied structures. These areas are vulnerable to natural disasters. If overtopping of embankment or breach of embankment occurs, these lands are transformed into wetlands again. All coastal polders, FC, D and FCD projects are included in this category.

The list of coastal polders as well as list of some major FCD projects of Bangladesh have been given in **Annexure 5: Reversible Wetlands**. Annexure 5 has two sections, 5A: List of Polders in Bangladesh and 5B: List of FCD Projects in Bangladesh.

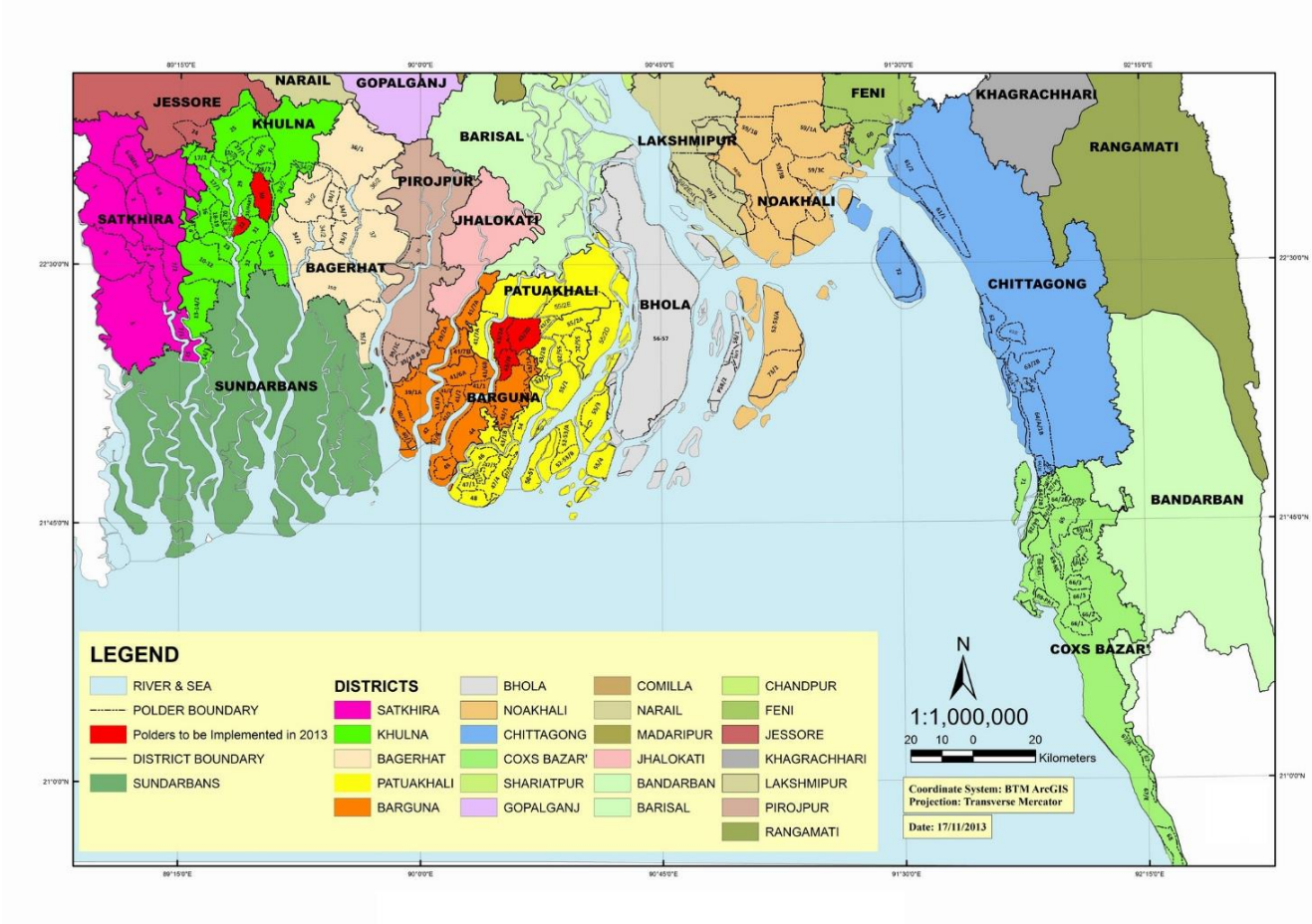


Figure 8.14: Coastal Polders of Bangladesh (Source: Blue Gold Program, 2013)

9 MAJOR FINDINGS

After reviewing the classification systems of wetlands (Ramsar, FGDC of the USA, Vietnamese, Indian etc.) and also considering perceived concept of wetlands, the Strategy for Classification Systems was developed (see Section 7.1). Thereafter, the Classification System of Wetlands of Bangladesh was prepared. The following are the major findings:

1. This classification system should be applied throughout Bangladesh, making it a national system.
2. It is strongly recommended that, Govt. of Bangladesh take immediate steps to approve this classification system of wetlands of Bangladesh and issue directives so that this system is used by individuals/organizations throughout the country.
3. Any new, updated, or revised mapping of wetlands of Bangladesh shall conform to this Wetlands Classification Standard.
4. Study on micro-level inventory of each type of wetlands should be taken up.
5. For carrying out such study, satellite images of finer resolution need to be collected. The DBHWD should immediately take up project on collection of satellite images both for monsoon and dry periods.
6. Study on ecological characteristics of wetlands (type-wise) should be taken up.
7. The DBHWD should initiate a programme for preparation of a video documentary on wetlands of Bangladesh according to the classification system.
8. Primary data have been collected from the field. Secondary data have been collected from different sources such as DBHWD, BWDB, SRDI, CEGIS, WARPO, IUCN and Internet. Compiling these data, 10 annexures have been prepared. The list of the annexures is given below:

    i. Annexure 1: Rivers of Bangladesh
    ii. Annexure 2: Haors of Bangladesh
    iii. Annexure 3: Maps of Wetlands of Bangladesh
    iv. Annexure 4: Beels of Bangladesh
    v. Annexure 5: Reversible Wetlands
    vi. 5A: List of Polders of Bangladesh
    vii. 5B: List of FCD projects of Bangladesh
    viii. Annexure 6: Biodiversity of Wetlands of Bangladesh
    ix. 6A: Plants of Inland Wetlands
    x. 6B: Plants of Sundarban Mangrove Forest

xi. 6C: Plants of Tanguar Haor
xii. 6D: Birds of Tanguar Haor
xiii. 6E: Animals of Tanguar Haor
xiv. 6F: Freshwater Fishes of Bangladesh
xv. Annexure 7: Feedback from the Workshops
xvi. Annexure 8: TOR of the Project.
xvii. Annexure 9: Soil Information of Wetlands of Bangladesh
xviii. Annexure 10: Wetland Photo Gallery

10 RECOMMENDATIONS

The major focus of the study was to develop the classification system of wetlands of Bangladesh. The inventory of the wetlands was beyond the scope of the study. However, macro level inventories of major inland wetlands (rivers, haors, beels) have been prepared and presented in Annexures 1, 2 & 4 respectively. The maps of wetlands were prepared and presented in the Annexure 3. The *Classification of Wetlands of Bangladesh* has been designed for using over a broad geographic area (all over Bangladesh) by individuals and organizations with varied interests and objectives. The definition of wetland in this classification focused on the central issue of hydrology and also to the biological extent of wetland, as influenced by the hydrologic characteristics at each site. This classification system is proposed to be applied throughout Bangladesh, making it a truly national system. The major recommendations of the study are given below:

1. Government of Bangladesh should approve this classification system of wetlands of Bangladesh and issue directives so that this system is used by individuals and organizations throughout the country.
2. Any new, updated, or revised mapping of wetlands of Bangladesh shall conform to this Wetlands Classification Standard.
3. Study on micro level inventory of each type of wetlands should be taken up.
4. For carrying out such study, satellite images of finer resolution need to be collected. The DBHWD should immediately take up project on collection of satellite images both during monsoon and dry period.
5. The DBHWD should take up a project on documentation of wetlands (video documentary and leaflets).
6. Study on ecological characteristics of wetlands (type wise) should be taken up.

References

Ahmed, Z.U., Begum, Z.N.T., Hassan, M.A., Khondker, M., Kabir, S.M.H., Ahmad, M., Ahmed, A.T.A., Rahman, A.K.A. and Haque, E.U. (eds) (2008). *Encyclopedia of Flora and Fauna of Bangladesh,* Vol 1, *Bangladesh Profile.* Asiatic Society of Bangladesh, Dhaka.

Alam, A.B.M.S., Chowdhury, M.S.M. and Sobhan, I. (2012). *Biodiversity of Tanguar Haor: A Ramsar Site of Bangladesh Volume I: Wildlife*. IUCN Bangladesh, Dhaka, Bangladesh.

Badrul Imam (1996). *Bangladesher Khaniz Sampad in Bangla (Mineral Resources of Bangladesh)*. Bangla Academy, Dhaka.

Bangladesh Bureau of Statistics (1998), *1998 Yearbook of Agricultural Statistics*. BBS, Dhaka.

Bangladesh Haor and Wetlands Development Board (2012). *Master Plan of Haor Areas.* BHWDB, Dhaka, Bangladesh.

Banglapedia (2003). *Bangladesh Geology.* [online] Available at: http://en.banglapedia.org/index.php?title=Bangladesh_Geology [Accessed 25th March, 2016]

Banglapedia (2003). *Wetland.* [online] Available at: http://en.banglapedia.org/index.php?title=Wetland [Accessed 14th February, 2016]

Begum, Z. N. T. (2008). *Encyclopedia of Flora and Fauna of Bangladesh,* Vol 1, *The Sundarbans: World's Largest Mangrove Forest.* Asiatic Society of Bangladesh, Dhaka.

Bergkamp G. & Orlando, B. (1999). *Wetlands and Climate Change Exploring collaboration between the Convention on Wetlands (Ramsar, Iran 1971) and the UN Framework Convention on Climate Change*. Ramsar Convention Secretariat, Gland, Switzerland.

Bergkamp, L. (2001). *Liability and Environment. Private and Public Law Aspects of Civil Liability for Environmental Harm in an International Context.* Kluwar Law International.

Brammer, H. (1996). *Geography of the Soils of Bangladesh.* University Press Limited. 1996.

Brammer, H. (2000). *Argo Ecological Aspects of Agricultural Research in Bangladesh.* University Press Limited.

Brammer, H. (2002). *Land Use and Land Use Planning in Bangladesh.* University Press Limited.

Brammer, H. (2012). *The Physical Geography of Bangladesh.* University Press Limited.

Braun D. (2010). *Bangladesh, India Most Threatened by Climate Change, Risk Study Finds*. National Geographic.

BWDB (1988). *Morphological Features of the Major Rivers of Bangladesh - Part 1*. Bangladesh Water Development Board, Dhaka.

Chowdhury, S. R. (2015). *Map of the Coastal Zone of Bangladesh*. University of Chittagong.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. (1979). *Classification of wetlands and deepwater habitats of the United States*. U.S. Fish and Wildlife Service, Washington DC.

David Braun (2010). *Bangladesh, India Most Threatened by Climate Change, Risk Study Finds*. National Geographic.

Department of Bangladesh Haor & Wetland Development (2015). PSP of Classification of Wetlands in Bangladesh. DBHWD, Dhaka.

Department of Environment (2015). *Fifth National Report to the Convention on Biological Diversity.* Ministry of Environment and Forests, Dhaka.

FAO/UNDP (1988). *Land Resources Appraisal of Bangladesh for Agricultural Development Report 2: Agro ecological Regions of Bangladesh*. FAO/UNDP.

Federal Geographic Data Committee (2013). *Classification of Wetlands and Deepwater Habitats of the United States.* Federal Geographic Data Committee Secretariat, Virginia, USA.

Flood Plan Coordination Organisation, Gob (1992). *Flood Action Plan 3: North Central Regional Water Management Project.*

Flood Plan Coordination Organisation, Gob (1992). *Flood Action Plan 6: Northwest Regional Water Management Project.*

Flood Plan Coordination Organisation, Gob (1993). *Flood Action Plan 4: Southwest Regional Water Management Project.*

Flood Plan Coordination Organisation, Gob (1993). *Flood Action Plan 5: Southeest Regional Water Management Project.*

Flood Plan Coordination Organisation, Gob (1994). *Flood Action Plan 2: Northeast Regional Water Management Project.*

Haroun Er Rashid (1991). *Geography of Bangladesh.* University Press Limited, Dhaka.

Hassan R, Scholes R, Ash N. (2005). *Ecosystems and human well-being. Current state and trends*. Island Press, Washington, DC.

International Union for Conservation of Nature (2012). *Biodiversity Of Tanguar Haor: A Ramsar Site Of Bangladesh: Volume I: Wildlife (Amphibians, Reptiles, Birds And Mammals).*

IPCC (2007). *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* IPCC, Geneva, Switzerland.

IUCN Bangladesh (2005). *Major Interventions For Sustainable Wetland Resource Management.* IUCN Bangladesh Country Office, Dhaka, Bangladesh.

Jim Thorsell, Renée Ferster Levy and Todd Sigaty (1997). *A Global Overview of Wetland and Marine Protected Areas on the World Heritage List*. IUCN, Gland, Switzerland.

Karim A, Hossain M (1957). *On the single calue climatic indices and the pedoclimatic zones of East Pakistan*. Orient Geogr.

Khan, F. H. (1991). *Geology of Bangladesh.* University Press Limited, Dhaka.

Khan, M., Monirul H. (2008). *Protected Areas of Bangladesh: A Guide to Wildlife*. Dhaka, Bangladesh: Nishorgo Program, Wildlife Management and Nature Conservation Circle, Bangladesh Forest Dept.

Lagrange, T. (2005). *Guide to Nebraska's Wetlands and Their Conservation Needs.* Nebraska Game and Parks Commission, USA.

Nhuan, M.T., Thu Ha, N. T., Quy, T. D., Ngoc N. T., Linh, D. T. T., Ngoc, N. T. M., Hue, N. T. H. H., Ngoc, P. B. (2008). *The Vietnamese Wetlands Classification System.* Vietnam National University, Hanoi, Vietnam.

Mastar Plan Organization (1986). *National Water Plan-I*.

Mastar Plan Organization (1991). *National Water Plan-II*.

Matthews, E., and I. Fung, (1987). *Methane emissions from natural wetlands: Global distribution, area, and environmental characteristics of sources.* Glob. Biogeochem. Cycles.

Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC.

Ministry of Law, Justice and Parliamentary Affairs, Legislative and Parliamentary Affairs Division, GoB (2013). *Bangladesh Water Act*. Ministry of Law, Justice and Parliamentary Affairs, Dhaka, Bangladesh.

Ministry of Planning, GoB (2008). Public Procurement Rules. Ministry of Planning, Dhaka, Bangladesh.

Ministry of Water Resources, GoB (1999). *National Water Policy.* Ministry of Water Resources, Dhaka, Bangladesh.

Ministry of Water Resources, GoB (2005). *Coastal Zone Policy.* Ministry of Water Resources, Dhaka, Bangladesh.

Qureshi, A.S., Ahmed, Z., Krupnik, T.J (2015). *Groundwater management in Bangladesh: An analysis of problems and opportunities. Research Report No. 2.* Cereal Systems Initiative for South Asia - Mechanization and Irrigation (CSISA-MI), Dhaka, Bangladesh.

Prain, David (1903). *Flora of the Sundribuns*: *Records of the Botanical Survey of India*. Volume II. Allied Book Centre, Calcutta. p. 251.

Ramsar Convention Secretariat (2013). *The Ramsar Convention Manual: a guide to the Convention on Wetlands (Ramsar, Iran, 1971), 6th ed*. Ramsar Convention Secretariat, Gland, Switzerland.

Reimann, K. U. (1993). *Geology of Bangladesh.* Gebrüder Borntraeger, Berlin-Stuttgart.

Russi D., ten Brink P., Farmer A., Badura T., Coates D., Förster J., Kumar R. and Davidson N. (2013). *The Economics of Ecosystems and Biodiversity for Water and Wetlands*. IEEP, London and Brussels; Ramsar Secretariat, Gland.

Scott, D.A. (1991). *Asia and the Middle East in Wetlands*. M. Finlayson and M. Moser (eds.). Oxford.

Sobhan, I., Alam, A. B. M. S. and Chowdhury, M. S. M. (2012). *Biodiversity of Tanguar Haor: A Ramsar Site of Bangladesh, Volume II: Flora*. IUCN Bangladesh Country Office, Dhaka, Bangladesh.

Space Applications Centre, Indian Space Research Organisation (2013). *National Wetland Inventory & Assessment*. Ministry of Environment and Forests, Govt. of India.

Sunny, Sanwar (2011). *Green Buildings, Clean Transport and the Low Carbon Economy: Towards Bangladesh's Vision of a Greener Tomorrow*. LAP Publishers, Germany.

APPENDIX A

Tributary, Distributary and Branches of the Major River Systems of Bangladesh

Table A-1: Brahmaputra-Jamuna River System

River	Tributary	Distributary	Branch
Brahmaputra-Jamuna	Teesta, Ghaghat, Dudhkumar, Dharla, Badai, Kageshwari, Girai	Monas	Hura Sagor
Teesta	Burail, Buri Teesta, Shemlajan	Ghaghat	Sati-Sarnamati-Bhateshwari
Ghaghat	Alai Kumari (Burail), Lenga	Alai	x
Dudhkumar	Phulkumar	x	x
Dharla	Maldaha, Gidari, Ratnai (Lalmonirhat)	x	x
Badai	Atrai (Pabna)	x	x
Hura Sagor	Bangali, Gohala, Atrai, Ichamati (Pabna)	x	x
Buri Teesta	Dhum, Kumlal-Nautara	x	x
Shemlajan	Singimari	x	x
Maldaha	x	Ratnai (Lalmonirhat)	x
Bangali	Kalapani, Ichamati (Bogra), Karatoya (Nilphamari), Katakhali (Gaibandha), Garaiya Khal	Banni, Kaludaha	Ichamati (Bogra-Sirajganj)
Gohala	Kaludaha	x	x
Atrai	Gadai, Chiknai, Choto Jamuna, Barnai, Baral Upper (Baral-Nandakuja)	Fakirni, Shib	Shirmakhali Khal, Atrai (Naogaon-Natore), Baral Lower (Pabna), Besani
Ichamati (Pabna)	x	Atrai (Pabna)	x
Ichamati (Bogra)	x	Garaiya Khal	x
Karatoya (Nilphamari)	Ghirnai, Nalshisa, Akhira-Maccha, Gangnai	Katakhali (Gaibandha), Nagar Lower (Bogra-Natore), Bhadai (Bogra)	Maila
Katakhali (Gaibandha)	Alai, Naleya	x	x

River	Tributary	Distributary	Branch
Banni	x	Gohala	x
Kaludaha	Banni	x	x
Ichamati (Bogra-Sirajganj)	Monas	x	x
Choto Jamuna	Khar Kharia-Tilai, Ciri, Guksi, Tulshi Ganga	Chhiri	x
Barnai	Fakirni	x	x
Baral Upper (Baral-Nandakuja)	Narode	Musakhan	N/A
Fakirni	Shib	x	x
Atrai (Naogaon-Natore)	Iramati, Nagar Lower (Bogra-Natore)	x	x
Besani	Bhadai (Bogra)	x	x
Ghirnai	x	x	Kala
Tulshi Ganga	Chhiri, Harabati	x	x
Musakhan	x	Narode	x
Old Brahmaputra	Jinjiram, Mora Jinjiram	Jhinai, Sitalakhya, Sutia, Banar Lower, Arial Khan (Narsingdi), Banar Upper, Aiman-Akhila	x
Jinjiram	x	Mora Jinjiram	x
Jhinai	Chatal	Jharkata, Chapai	Bairan
Sitalakhya	Balu, Banar Lower	Nagda Khal	x
Sutia	x	Mahari	Pagaria-Shila
Banar Lower	Sutia, Khiro (Bhaluka)	x	x
Banar Upper	Aiman-Mobari	Bangshi, Khiro (Trishal), Bajja-Medhua	x
Aiman-Akhila	x	Aiman-Mobari	x

River	Tributary	Distributary	Branch
Balu	Tungi Khal, Nagda Khal, Chilai	x	x
Khiro (Bhaluka)	Baksatra, Bajja-Medhua	x	x
Khiro (Trishal)	Mahari, Aiman-Akhila	x	x
Bangshi	Jhinai, Louhajang, Tanki Khal, Hai	Turag, Boshkhalir Khal	Nangli
Louhajang	Alongjani, Boshkhalir Khal	x	x
Hai	Nangla, Chapai	x	x
Turag	Bangshi (Savar), Salda, Labundha, Goallar Khal	Tungi Khal, Buriganga	x
Nangli	Pungli, Hai	x	x
Salda	Ghungghur	x	x
Dhaleswari	Bangshi, Buriganga, Sitalakhya, Ichamati (Serajdikhan)	Pungli, Alongjani, Louhajang, Bangshi (Savar)	Kaliganga (Manikganj), Gazikhali
Ichamati (Serajdikhan)	Taltala Khal	x	x
Kaliganga (Manikganj)	Old Dhaleswari, Gangdubi	x	x
Old Dhaleswari	x	Gangdubi	x

(Note: Underlined rivers do not have any tributary, distributary or branch.)

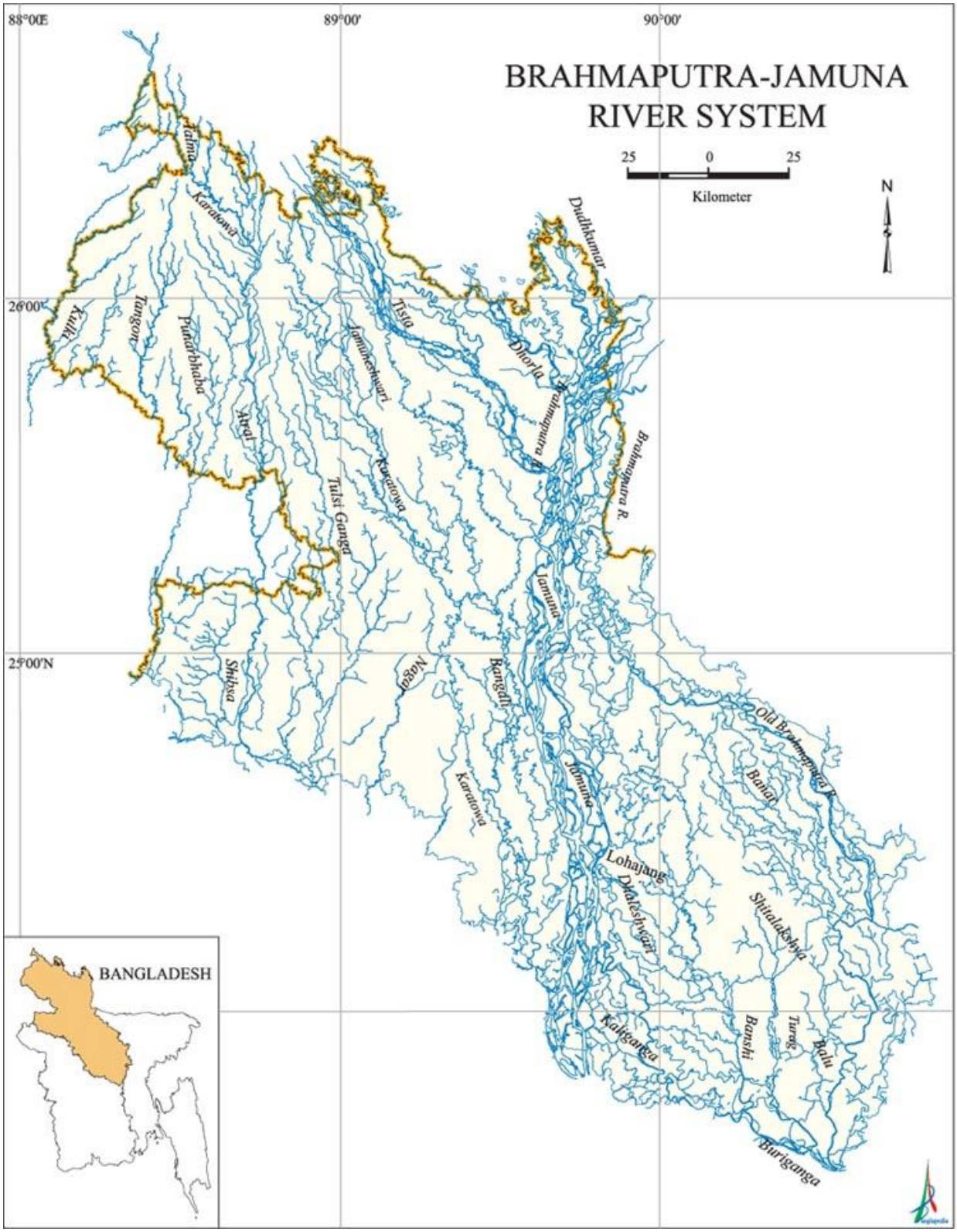


Figure A-1: Brahmaputra-Jamuna River System

Table A-2: Ganges-Padma River System

River	Tributary	Distributary	Branch
Ganges (Padma)	Mahananda Lower (Nawabganj)	Baral Upper (Baral-Nandakuja), Mathabhanga, Garai, Ichamati (Pabna), Badai, Chandana-Barasia	x
Mahananda Lower (Nawabganj)	Punarbhaba, Pagla	x	x
Baral Upper (Baral-Nandakuja)	Narode	Musakhan	N/A
Mathabhanga	Hisna-Jhanja	Nabaganga, Kumar (Chuadanga)	x
Garai	Chatra	x	Sirajpur Haor
Ichamati (Pabna)	x	Atrai (Pabna)	x
Badai	Atrai (Pabna)	x	x
Punarbhaba	Dhepa, Narth	x	x
Musakhan	x	Narode	x
Nabaganga	Kumar (Chuadanga)	Fatki, Katakhali (Narail)	x
Sirajpur Haor	x	Chatra	x
Dhepa	Choto Dhepa	x	x
Fatki	Begabati	x	x
Choto Dhepa	Patharghata, Bhulli	x	x
Padma	Ichamati (Manikganj), Katakhali	Taltala Khal, Joypara Khal, Ilishmari	x
Ichamati (Manikganj)	Joypara Khal, Ilishmari	Ichamati (Serajdikhan)	x
Ichamati (Serajdikhan)	Taltala Khal	x	x

(Note: Underlined rivers do not have any tributary, distributary or branch.)

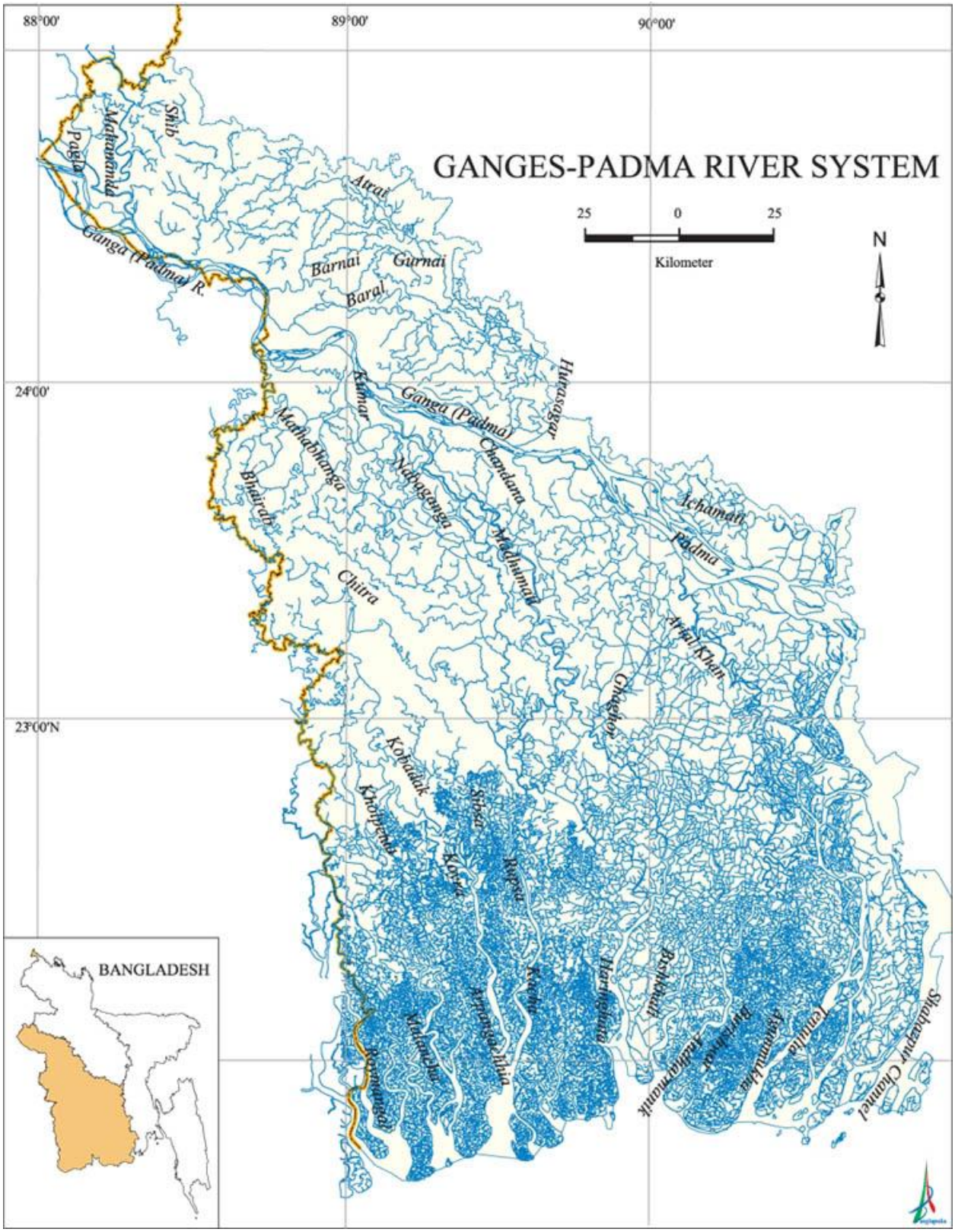


Figure A-2: Ganges-Padma River System

Table A-3: Surma-Meghna River System

River	Tributary	Distributary	Branch
Surma	Lubha, Pabijuri-Kusi Gang-Kusiya, Sari Gowain, Noya Gong (Khasiamara), Khasimara, Jalukhali (Chalti), Piyain (Sylhet-Sunamganj), Jadukata-Rakti	Bhabna-Bashia-Bahia Gang, Botor Khal, Piyain (Sunamganj-Netrakona), Old Surma	x
Lubha	Amri Khal	x	x
Pabijuri-Kusi Gang-Kusiya	Khepa, Nokla-Sundrakasi	Kapna, Koris	x
Sari Gowain	Lain, Naya Gang (Jaintiapur), Jaflong-Dauki, Kapna	Bar Gang, Pora Khal-Khaiya, Bekra	x
Piyain (Sylhet-Sunamganj)	Dhala, Jalia Chara (Bholaganj), Chela	x	x
Jadukata-Rakti	x	Patnai Paikartala, Baulai (Balua)	x
Botor Khal	x	Dauka	x
Piyain (Sunamganj-Netrakona)	Kaldahar-Kanyakul	x	x
Amri Khal	x	Nokla-Sundrakasi	x
Nokla-Sundrakasi	x	Lain	x
Kapna	Bekra, Pora Khal-Khaiya	x	x
Naya Gang (Jaintiapur)	Bar Gang	x	x
Pora Khal-Khaiya	Koris	Khepa	x
Jalia Chara (Bholaganj)	Umiyam	x	x
Baulai (Balua)	Patnai Paikartala, Surma, Someswari (Dharmapasha), Bhogai Kangsho	Kaldahar-Kanyakul	x
Kaldahar-Kanyakul	Dolta	x	x
Bhogai Kangsho	Malijhi, Ghagtia, Netai	x	x
Malijhi	Moharoshi	x	x
Ghagtia	Satar Khali	x	x

River	Tributary	Distributary	Branch
Netai	x	Satar Khali	Bedori Khal
Meghna (Upper)	Dasadia, Longon Bolvodra, Titas (Narsingdi Sadar-Bancharampur)	N/A	Titas, Dhanagoda
Longon Bolvodra	Kasti	x	x
Titas (Narsingdi Sadar-Bancharampur)	Arsi-Nalia	x	x
Titas	Buri, Bijni, Lahar, Sonai	Dasadia	x
Sonai	x	Kasti	x
Meghna (Lower)	Dakatia	x	x

(Note: Underlined rivers do not have any tributary, distributary or branch.)

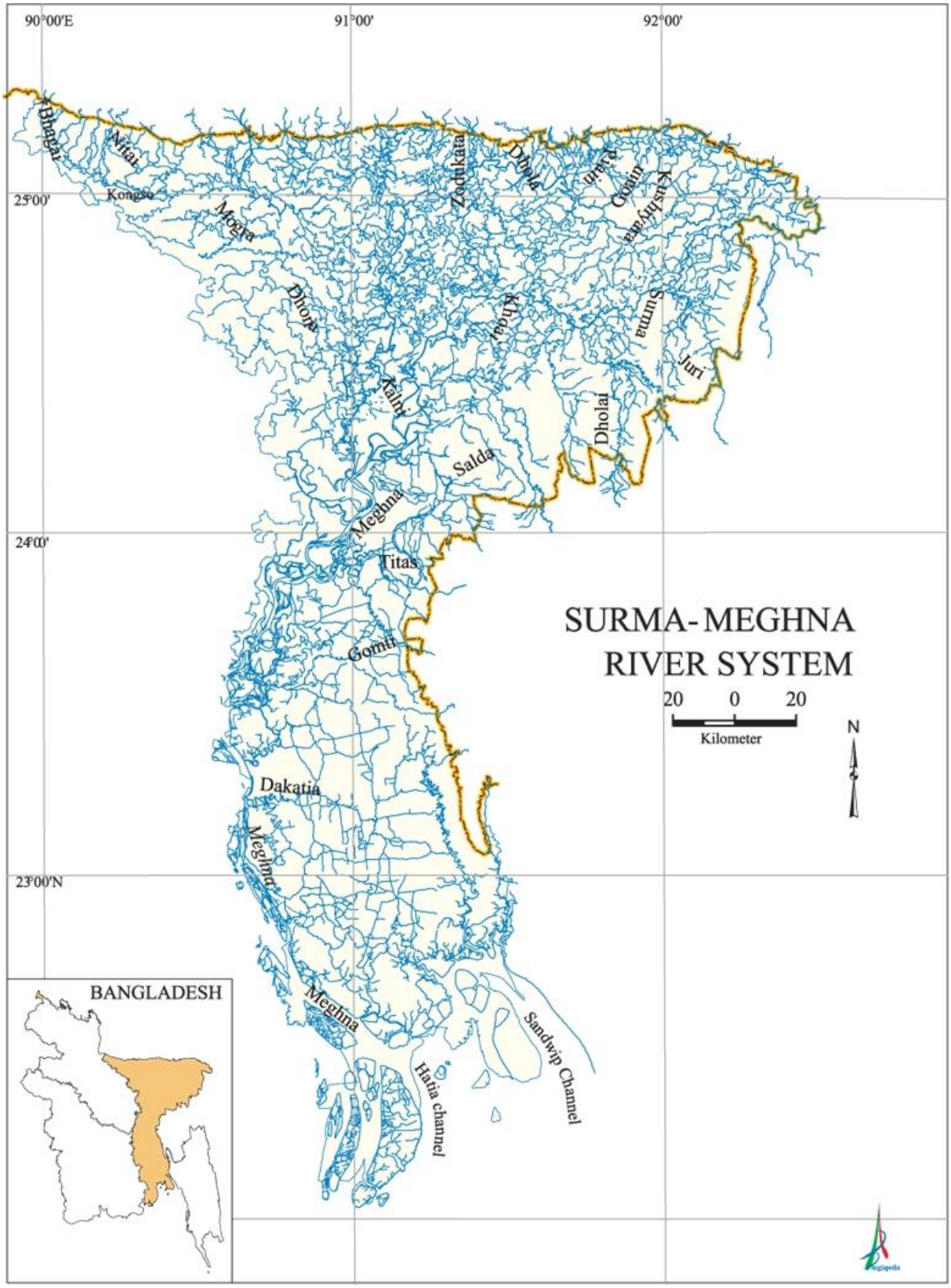


Figure A-3: Surma-Meghna River System

Table A-4: Chittagong Region River System

River	Tributary	Distributary	Branch
Karnafuli	Ichamati, Halda, Tuilianpui or Sazal Lui, Thega or Kawpui, Shuvalong-maram Chhara, Bhandarjuri Khal, Sylok Khal, Hirar Chhara	x	x
Halda	Dhurong Khal, Sarta Khal, Bowalia Khal	x	x
Kasalang	Gangaram Chhara, Shishok Chhara, Maini	x	x
Bakkhali	Dochhari Chhara	x	x
Maini	Chaudharalma Chhara, Choto Merung Chhara	x	x
Matamuhuri	Lama Chhara, Popa or Bopa Chhara, Bamu Khal, Eyanchi Khal	Bura Matamuhuri, Bholakhal	x
Rangkhaing	Gaba Chhara	x	x
Sangu	Dolu Khal-Tankabati Khal, Sowark Chhara	x	x
Chingri (Chengi)	x	x	x
Naf	x	x	x
Bharuakhali Khal	x	x	x
Eidgoan	x	x	x

(Note: Underlined rivers do not have any tributary, distributary or branch.)

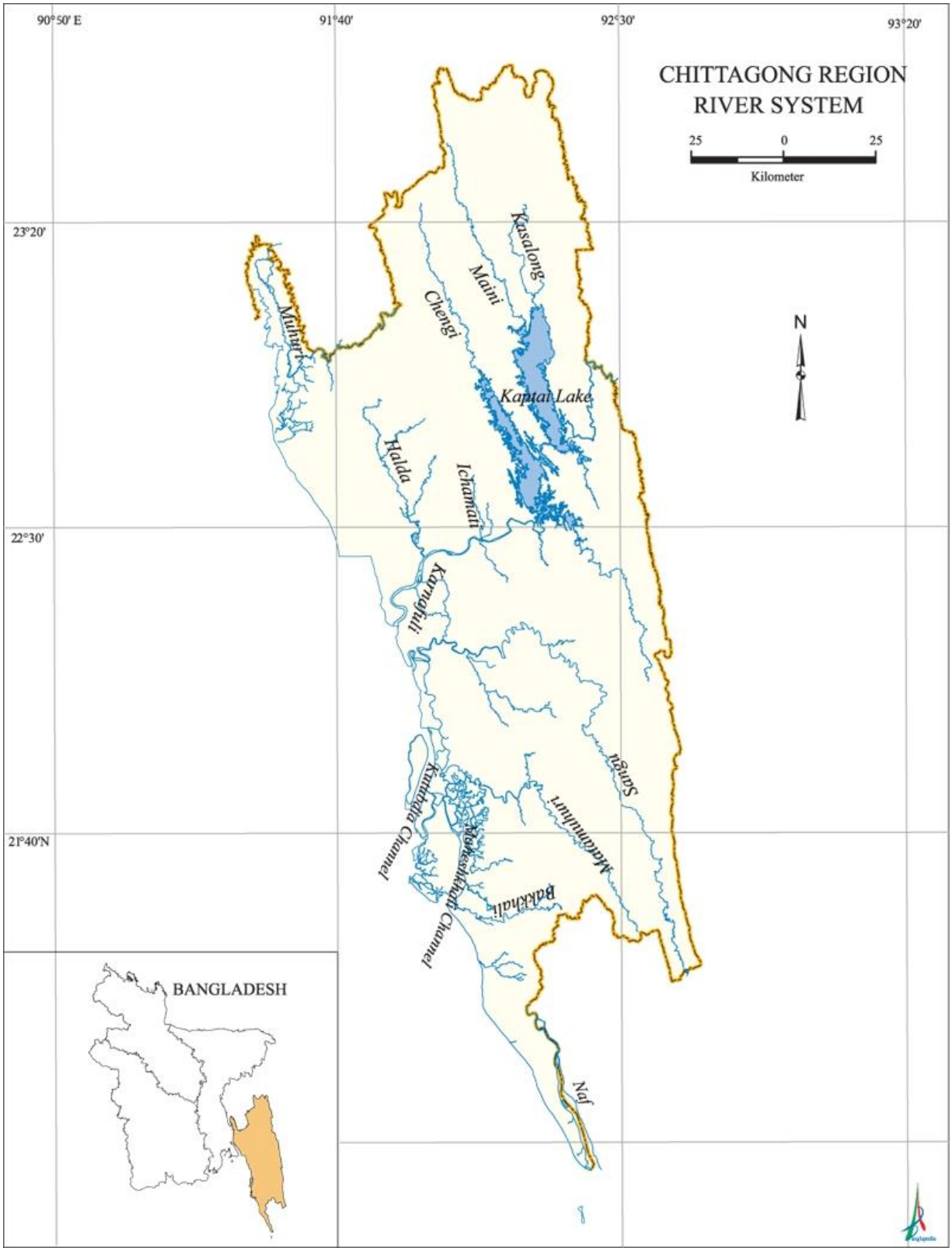


Figure A-4: Chittagong Region River System

APPENDIX B

Bangla Translation of Executive Summary

নির্বাহী সারসংক্ষেপ

জলাভূমি সমূহ সমৃদ্ধ জীববৈচিত্রে পরিপূর্ণ। এই জলাভূমি ও জীববৈচিত্র পরিবেশগত ও অর্থনৈতিক দিক থেকে খুবই গুরুত্বপূর্ণ। বাংলাদেশের সংবিধানের ১৮.ক অনুচ্ছেদে জলাভূমিসমূহের নিরাপদ সংরক্ষণের বিষয়ে উল্লেখ আছে।

“১৮/ক. রাষ্ট্র বর্তমান ও ভবিষ্যৎ না গরিকদের জন্য পরিবেশ সংরক্ষণ ও উন্নয়ন করিবেন এবং প্রাকৃতিক সম্পদ, জীববৈচিত্র, জলাভূমি, বন ও বন্য প্রাণির সংরক্ষণ ও নিরাপত্তা বিধান করিবেন।

জলাভূমি সমূহ ও এগুলোর সংরক্ষণের গুরুত্ব বিবেচনা করে বাংলাদেশ সরকার কতিপয় আইন প্রণয়ন করেছে, যেমন: বাংলাদেশ পানি আইন , ২০১৩, বাংলাদেশ পরিবেশ সংরক্ষণ আইন, ১৯৯৫, বাংলাদেশ পরিবেশ সংরক্ষণ আইন, (সংশোধিত) ২০১০, জলাধার সংরক্ষণ আইন, ২০০০, জাতীয় নদী সংরক্ষণ কমিশন আইন, ২০১৩ ইত্যাদি। এছাড়াও, জাতীয় পানি নীতি , পরিবেশ নীতি, মৎস্য নীতি ইত্যাদি নীতিমালায় জলাভূমি সংক্রান্ত নীতিও নির্দেশনা বর্ণিত আছে।

বাংলাদেশ বিভিন্ন আন্তর্জাতিক কনভেনশন ও প্রোটকল (convention and protocol) যেমন: রামসার কনভেনশন, এমডিজি, এসডিজি ইত্যাদিতে স্বাক্ষরকারী দেশ হিসাবে জলাভূমির উন্নয়ন ও সংরক্ষণে প্রতিজ্ঞাবদ্ধ। পরিবেশ অবক্ষয়ের কারণে সংকটাপন্ন বা সং কটাপন্ন হওয়ায় আশংকাযুক্ত প্রতিবে শ ব্যবস্থা (ecosystem system) সংরক্ষণ, প্রতিরোধ ও পুনরূদ্ধার করার লক্ষ্যে বাংলাদেশ সরকার ইতোমধ্যে ১৩টি এলাকাকে ‘পরিবেশগত সংকটাপন্ন এলাকা ’ (ecologically critical area) হিসাবে ঘোষণা করেছে। লক্ষনীয় যে, সবগুলো প্রতিবেশগত সংকটাপন্ন এলাকাই (ইসিএ) জলাভূমির অন্তর্গত।

বাংলাদেশে নদী, প্লাবনভূমি, হাওর, বাওর, বিল, ঝিল, পুকুর, নিম্নভূমি ইত্যাদিকে সাধারনভাবে জলাভূমি হিসাবে গণ্য করা হয়। এছাড়াও মৌসুমী অভ্যন্তরীণ প্লাবনভূমি ও জোয়ারের প্রভাবে প্লাবিত উপকূলীয় নিম্নভূমিসমূহও জলাভূমির অন্তর্ভূক্ত। বাংলাদেশ পানি আইন, ২০১৩ এ জলাভূমিকে নিম্নোক্তভাবে সংজ্ঞায়িত করা হয়েছে :

“জলাভূমি” অর্থ এমন কোন ভূমি যেখানে পানির উপরিতল ভূমিতলের সমান বা কাছাকাছি থাকে বা যাহা , সময়ে সময়ে, স্বল্প গভীরতায় নিমজ্জিত থাকে এবং যেখানে সাধারণত ভিজা মাটিতে জন্মায় এবং টিকিয়া থাকে এমন উদ্ভিদাদি জন্মায়;

রামসার কনভেনশন, ১৯৭১ অনুসারে জলাভূমির সংজ্ঞা হল:-

“প্রাকৃতিক অথবা মানবসৃষ্ট স্থায়ী অথবা অস্থায়ী , স্থির অথবা প্রবাহমান পানিরাশি বিশিষ্ট স্বাদু , লবণাক্ত বা মিশ্র পানি বিশিষ্ট জলা, ডোবা, পিটভূমি বা পানি সমৃদ্ধ এলাকা ও সেই সঙ্গে এমন গভীরতা বিশিষ্ট সামুদ্রিক এলাকা যা নিম্ন জোয়ারের সময় ৬ মিটারের বেশি গভীরতা অতিক্রম করে না ”। উপরন্তু (জলাভূমি) সংলগ্ন এলাকা রক্ষার্থে ‘রামসার আন্তর্জাতিক গুরুত্বপূর্ণ জলাভূমি’ তালিকায় “জলাভূমি সংলগ্ন নদীতীরবর্তী ও উপকূলীয় অঞ্চলসমূহ, দ্বীপ বা ছয় মিটারের অধিক গভীর (নিম্ন জোয়ারে) নিজ্জিত জলাভূমিকেও অন্তর্ভুক্ত করতে হবে”।
হ্রদ ও নদীসমূহকে তাদের গভীরতা নির্বিশেষে রামসার কনভেনশনের জলাভূমির সংজ্ঞায় অন্তর্ভূক্ত করা হয়েছে।

সাধারনভাবে এই প্রতিবেদনের মূল উদ্দেশ্য হচ্ছে রামসার শ্রেণীবিন্যাস কাঠামো অনুসরণে বাংলাদেশের জলাভূমির একটি শ্রেণী বিন্যাস পদ্ধতি (system) প্রণয়ন করা। এছাড়াও, জলাভূমি চিহ্নিতকরণের লক্ষে ম্যাক্রো লেভেল (macro level) মানচিত্র প্রস্তুত করা ও গুরুত্বপূর্ণ জলাভূমির তালিকা প্রণয়ন করাও এই প্রতিবেদনের উদ্দেশ্য। এই শ্রেণীবিন্যাস পদ্ধতিটি জাতীয় পদ্ধতি হিসেবে , সরকারি সংস্থা , একাডেমিক, বেসরকারি সংস্থা, গবেষক, সতন্ত্র ব্যক্তি ইত্যাদি কর্তৃক ব্যবহৃত হবে বলে আশা করা যায়। সমগ্র রিপোর্টটি মোট ৮ (আট) টি খন্ডে বিভক্ত : একটি প্রধান খন্ড এবং অন্যান্য ৭টি খন্ডে ১০টি সংযোজনী দেয়া হয়েছে। সংযোজনীগুলোতে জলাভূমির (ম্যাক্রো লেভেলে) সনাক্তকরণ, গুরুত্বপূর্ণ প্রকল্প দলিল, স্টেকহোল্ডারদের (stakeholder) মতামত ও পরামর্শ ইত্যাদি বর্ণিত হয়েছে।

বাংলাদেশের জলাভূমিসমূহের শ্রেণীবিন্যাসকরণে বিভিন্ন প্রকাশনা , প্রতিবেদন, নীতি, আইন ইত্যাদি গবেষক দল দ্বারা পর্যালোচিত হয়েছে। এর মধ্যে উল্লেখযোগ্য দলিল (document)সমূহ হলো:

- রামসার কনভেনশন ম্যানুয়াল, ১৯৭১

- ক্লাসিফিকেশন অফ ওয়েটল্যান্ডস এন্ড ডিপ ওয়াটার হ্যাবিটেট অফ ইউনাইটেড স্টেটস, এফজিডিসি, ২০১৩
- দি ভিয়েতনামিজ ওয়েটল্যান্ডস ক্লাসিফিকেশন সিস্টেম ,২০০৮
- ন্যাশনাল ওয়েটল্যান্ড এটলাস : লাক্ষাদ্বিপ, ইন্ডিয়ান স্পেস রিসার্চ অর্গানাইজেশন, ২০০৯
- মাষ্টার প্ল্যান অফ হাওর এরিয়াস, বিএইচডব্লিউবি, ২০১২
- ন্যাশনাল ওয়াটার পলিসি অফ বাংলাদেশ,১৯৯৯
- কোষ্টাল জোন পলিসি অফ বাংলাদেশ,২০০৫

এই প্রতিবেদনটি প্রণয়নের প্রাথমিক কর্মপদ্ধতি (methodology) প্রারম্ভিক প্রতিবেদনে (Inception Report) বর্ণিত হয়েছে, যা প্রকল্পের কারিগরী কমিটি ও বাংলাদেশ হাওর ও জলাভূমি উন্নয়ন অধিদপ্তর কর্তৃক অনুমোদিত হয়েছে। মধ্যবর্তী প্রতিবেদন (Mid Term Report)ও (খসড়া) চূড়ান্ত প্রতিবেদন (draft Final Report) প্রণয়নের ক্ষেত্রেও সেই একই কর্মপদ্ধতির পরিমার্জিত ও সমন্বিত সংস্করণ ব্যবহৃত হয়েছে। সমীক্ষাটি মূলত: সেকেন্ডারি উৎসের তথ্য ও উপাত্তের উপর ভিত্তি করে প্রণীত হলেও দেশের ৬৪টি জেলা হতে বিভিন্ন মৌলিক (primary) তথ্য ও উপাত্ত যেমন : জলজ উদ্ভিদ, পাখি, আলোকচিত্র, মৃত্তিকার নমুনা ইত্যাদি অতি সাধারনভাবে স্পট পরীক্ষণ (spot checking) এর উদ্দেশ্যে সংগ্রহ করা হয়েছে।

প্রকল্প পর্যবেক্ষণ সভার সিদ্ধান্তের প্রেক্ষিতে পৃথক পৃথক সংযোজনীতে (সংযোজনী ৬ ও ৯) মৃত্তিকা পরিমিতি (parameters) ও উদ্ভিদ সম্পর্কিত তথ্য-উপাত্ত উপস্থাপন করা হয়েছে। জলজ উদ্ভিদ, পাখি ও মৃত্তিকার শ্রেণীবিন্যাস তালিকা প্রাসঙ্গিক সেকেন্ডারি উৎস হতে সংগৃহীত হয়েছে যার বিশ্লেষণ পৃথক সংযোজনীতে দেয়া হয়েছে।

বাংলাদেশে প্রাকৃতিক ভৌগলিক বিভিন্নতা পরিলক্ষিত হয় এবং এর দুটি স্বাতন্ত্রসূচক বৈশিষ্ট্য বিদ্যমান: গঙ্গা-ব্রহ্মপুত্র -মেঘনা নদী সিস্টেম দ্বারা গঠিত বদ্বীপ এবং অনুচ্চ পার্বত্য অঞ্চল। ভৌগলিক প্রেক্ষাপটের ভিত্তিতে বাংলাদেশকে তিনটি স্বতন্ত্র অঞ্চলে বিভক্ত করা যায় : প্লাবণভূমি (flood plains), সোপান (terraces) ও পাহাড়ী অঞ্চল (hills)।

বাংলাদেশকে ভৌগলিক ও প্লাবণভূমির তুলনায় ভূমির উচ্চতা ও কৃষিজ-জলবায়ুর ভিত্তিতে ৩০টি কৃষি প্রতিবেশগত অঞ্চলে (agro-ecological zone) ভাগ করা হয়েছে।

বাংলাদেশের নদ-নদীসমূহ চারটি প্রধান সিস্টেমে বিভক্ত:

(১) ব্রহ্মপুত্র-যমুনা সিস্টেম;

(২) গঙ্গা-পদ্মা সিস্টেম;

(৩) সুরমা-মেঘনা সিস্টেম; ও

(৪) চট্টগ্রাম অঞ্চলের নদী সিস্টেম;

ভূতাত্বিক উৎস অনুসারে বাংলাদেশের স্থলভূমি ৭(সাত) টি ভূভাগে বিভক্ত : মধুপুর গড়, বরেন্দ্র ভূমি, তিস্তা পলল ভূমি, ব্রহ্মপুত্র পলল ভূমি, গাঙ্গেয় পলল ভূমি, উপকূলীয় লবণাক্ত অঞ্চল ও পার্বত্য চট্টগ্রাম অঞ্চল।

জলবায়ুকে ভৌগলিক অবস্থার সর্বাধিক সক্রিয় উপাদান বিবেচনা করে বাংলাদেশকে তিনটি জলবায়ু-ভৌগলিক অঞ্চলে ভাগ করা হয়েছে: আর্দ্র (humid), আংশিক/ঈষৎ আর্দ্র (semi-humid) এবং আংশিক/ঈষৎ শুষ্ক (feebly arid) অঞ্চল। এদেশের একক বৃহত্তম ভূমি ব্যবহারের অধিক্ষেত্র হচ্ছে কৃষি । আবাদী (arable) জমির পরিমাণ প্রায় ৯ মিলিয়ন হেক্টর (২২ মিলিয়ন একর), বনভূমি ২.২৫ মিলিয়ন হেক্টর (৫.৫ মিলিয়ন একর) এবং জলাভূমি ও জ নবসতি ৩ মিলিয়ন হেক্টর (৭.৫ মিলিয়ন একর) (ব্রামার, ২০০৪)। বাংলাদেশের জলবায়ু গ্রীষ্মমন্ডলীয়/ক্রান্তীয় ও আর্দ্র (tropic and humid)। এখানে চারটি বৈশিষ্ট্যপূর্ণ স্বতন্ত্র ঋতু পরিলক্ষিত হয়: প্রাক বর্ষা (মার্চ-মে), বর্ষা (জুন-সেপ্টেম্বর), বর্ষা পরবর্তী (অক্টোবর-নভেম্বর) ও শুষ্ক মৌসুম (ডিসেম্বর-ফেব্রুয়ারী)। জলবায়ু পরিবর্তন ও বৈশ্বিক উষ্ণতা বৃদ্ধিতে বাংলাদেশের উপর সম্ভাব্য প্রভাবসমূহ হলো:

(১) সমুদ্রপৃষ্ঠের উচ্চতা বৃদ্ধি ২০৩০ ও ২০৭৫ সাল নাগাদ যথাক্রমে ৩০০ মিমি ও ৭০০ মিমি। সুতরাং, প্রতি বৎসরে ১০ মিমি হারে উচ্চতা বৃদ্ধি ও ২০২৫ সাল নাগাদ ২৫০ মিমি উচ্চতা বৃদ্ধির সম্ভাবনা রয়েছে।

(২) বর্ষা মৌসুমে ২০৩০ ও ২০৫০ সাল নাগাদ যথাক্রমে ০.৭° সে. ও ১.১° সে. তাপমাত্রা বৃদ্ধির সম্ভাবনা রয়েছে। শুষ্ক মৌসুমে ২০৩০ ও ২০৫০ সাল নাগাদ যথাক্রমে ১.৩° সে. ও ১.৮° সে. উষ্ণতা বৃদ্ধির সম্ভাবনা রয়েছে।

(৩) মৌসুমী বৃষ্টিপাত ২০৩০ ও ২০৫০ সাল নাগাদ যথাক্রমে প্রায় ১০% ও ২৫% পর্যন্ত বৃদ্ধির সম্ভাবনা রয়েছে। দীর্ঘমেয়াদে শুষ্ক মৌসুমে বৃষ্টির পরিমাণ হ্রাস পাওয়ার সম্ভাবনা রয়েছে।

বাংলাদেশের জলাভূমির শ্রেণীবিন্যাস কাঠামো মূল ত রামসার শ্রেণীবিন্যাসের ভিত্তিতে প্রণীত হলেও বাংলাদেশের অবস্থানের বিবেচনায় এতে বেশ কিছু পরিবর্তন, পরিমার্জন ও সংযোজন করা হয়েছে। কেন্দ্রীয় ইস্যু হিসাবে হাইড্রোলজিক্যাল বিবেচনাকে ভিত্তি করে এই শ্রেণীবিন্যাস পদ্ধতিটি প্রণীত হয়েছে।

বাংলাদেশে অভ্যন্তরীণ ও উপকূলীয় উভয় অঞ্চলে বন্যা নিয়ন্ত্রণের জন্য বাঁধ ও অন্যান্য অবকাঠামো নির্মিত হয়েছে। সুতরাং বাঁধ বা পোল্ডার দ্বারা সুরক্ষিত বন্যামুক্ত অঞ্চলসমূহকে আর জলাভূমি হিসেবে গণ্য করা যায় না। তথাপি, প্রাকৃতিক দুর্যোগ যেমন : ঘূর্ণিঝড়, নদী ভাঙ্গান ইত্যাদির প্রভাবে ও অন্যান্য কারণে বাঁধের ফাটল/ভাঙ্গান ও ক্ষয়ক্ষতির আশঙ্কা/হুমকি আছে। বাঁধ মেরামত বা পুন :নির্মাণ করার আগ পর্যন্ত ভাঙ্গানে ক্ষতিগ্রস্থ বাঁধ সংলগ্ন এলাকা নিয়মিতভাবে বন্যায় প্লাবিত হয়। সুতরাং পূর্বে বাঁধ বা পোল্ডার দ্বারা সংরক্ষিত বন্যামুক্ত অঞ্চলগুলো পুনরায় জলাভূমিতে পরিণত হওয়ার আশঙ্কা রয়েছে। অতএব একটি নূতন পরিভাষার (terminology), 'পূর্ববর্তী অবস্থায় ফেরৎযোগ্য/রিভার্সিবল জলাভূমি' অবতারণা করা হয়েছে। যেসব অঞ্চল বন্যামুক্ত কিন্তু বাঁধ, বন্যা নিয়ন্ত্রণ অবকাঠামোর ভাঙ্গান বা ক্ষয়ক্ষতি বা প্রত্যাহারের ফলস্রুতিতে পুনরায় বন্যা কবলিত হওয়ার আশঙ্কা আছে তাদের রিভার্সিবল (Reversible) জলাভূমি হিসাবে সঙ্গায়িত করা হয়েছে। পরিবেশগতভাবে অবনমিত (environmentally degraded) , কিন্তু পূনরুদ্ধার যোগ্য জলাভূমিও এর অন্তর্ভুক্ত। বাংলাদেশ হাওর ও জলাভূমি উন্নয়ন অধিদপ্তরের সাথে রিভার্সিবল জলাভূমি এর ধারণা সম্পর্কেআলোচনা করা হয়েছে এবং বাংলাদেশ হাওর ও জলাভূমি উন্নয়ন অধিদপ্তর কর্তৃক ধারণাটি সমর্থিত/অনুমোদিত হয়েছে।

বাংলাদেশের জলাভূমিসমূহ শ্রেণীবিন্যাসকরণে র লক্ষ্যে একটি কৌশল (strategy) প্রণীত হয়েছে, যা বাংলাদেশ হাওর ও জলাভূমি উন্নয়ন অধিদপ্তর কর্তৃক অনুমোদিত। কৌশলগুলো নিম্নে বর্ণিত হলো:

(১) রামসার কনভেনশনে সংজ্ঞায়িত জলাভূমির অনুরুপ সংজ্ঞা অনুসরণ করা হবে।

(২) সামগ্রিক ভাবে জলাভূমির রামসার শ্রেণীবিন্যাসের কাঠামোর উপর ভিত্তি করে এই শ্রেণীবিন্যাস প্রণীত হবে।

(৩) এই শ্রেণীবিন্যাস টি জলাভূমির কেন্দ্রীয় ইস্যু অর্থাৎ **হাইড্রোলজি** (hydrology) এর ভিত্তিতে প্রণীত হবে।

(৪) ভৌগলিক ও পরিবেশগত অবস্থার উপর বিবেচনা করে এবং রামসার কাঠামো অনুসরণে বাংলাদেশের জন্য সুনির্দিষ্ট এই শ্রেণীবিন্যাস প্রণীত হবে।

(৫) রামসার শ্রেণীবিন্যাসে ৩(তিন) টি সিস্টেমের (system) জলাভূমির উল্লেখ থাকলেও বাংলাদেশের জন্য সুনির্দিষ্ট এই নতুন শ্রেণীবিন্যাসে ৪(চার) টি সিস্টেমের জলাভূমির উল্লেখ থাকবে। এখানে, নতুন আরও এক সিস্টেমের জলাভূমি, যথা: রিভার্সিবল জলাভূমি (Reversible Wetland) বিবেচনা করা হবে।

(৬) উদ্ভিদ ও মৃত্তিকা সম্পর্কিত সংগৃহীত তথ্য ও উপাত্তসমূহ লিপিবদ্ধ করা হবে ও সংযোজনীতে পেশ করা হবে।

(৭) রিভার্সিবল জলাভূমি (Reversible Wetland) ব্যতীত অন্যান্য প্রত্যেক সিস্টেমের জলাভূমিকে দুটি শ্রেণীতে (class) বিভক্ত করা হয়েছে, যথা:- স্থায়ী ও অস্থায়ী।

ছক ৭.২ এ প্রদর্শিত বাংলাদেশের জলাভূমিসমূহের শ্রেণীবিন্যাসটি ৪(চার) টি সিস্টেম (system), ২(দুই) টি শ্রেণী (class) ও ৩০ (ত্রিশ) টি প্রকার/ধরণে (type) এ বিভক্ত। এই শ্রেণীবিন্যাস পদ্ধতিটি 'অধ্যায় ৭' এ বিশদভাবে বর্ণিত হয়েছে। নামকরণ পদ্ধতিটি রামসার শ্রেণীবিন্যাসের সাথে সামঞ্জস্য রেখে প্রণীত হয়েছে। উদাহরণস্বরূপ: 'BA' টাইপ (type) এখানে 'B' দ্বারা বাংলাদেশ (Bangladesh) এবং 'A' দ্বারা রামসার শ্রেণীবিন্যাসের 'A টাইপ' (type) বোঝানো হয়েছে (যা, স্থায়ী অগভীর সামুদ্রিক জলাভূমি , অধিকাংশ ক্ষেত্রে ভাটার সময় ৬(ছয়) মিটার গভীরতার কম থাকে; সমুদ্র উপকূল (sea bay) ও প্রণালী (straits) এর অন্তর্গত।

বাংলাদেশ শ্রেণীবিন্যাস পদ্ধতিটি রামসার , যুক্তরাষ্ট্রের এফজিডিসি (FGDC), ভিয়েতনাম ও ভারতের শ্রেণীবিন্যাস পদ্ধতির সাথে তুলনা করা হয়েছে।

এই সমীক্ষা কাজটির (study) মূল লক্ষ্য হলো বাংলাদেশের জলাভূমিসমূহের শ্রেণীবিন্যাস সিস্টেম প্রণয়ন করা। এই শ্রেণীবিন্যাসে বর্ণিত জলাভূমির সংজ্ঞায় জলাভূমির জৈবিক ব্যাপ্তি (biological extent), (যা প্রতিটি এলাকার হাইড্রলজিক site hydrologic বৈশিষ্ট্য দ্বারা প্রভাবিত), অন্তর্ভূক্ত নয়। জলাভূমির বিস্তারিত তালিকা (inventory) প্রণয়ন করা সমীক্ষার কার্যক্ষেত্রে র অন্তর্ভূক্ত ছিল না। তবে প্রধান

অভ্যন্তরীণ জলাভূমিসমূহের (হাওর, নদী, বিল, রিভারসিবল জলাভূমি ইত্যাদি) ম্যাক্রো লেভেল তালিকা (inventory) প্রস্তুত করে সংযোজনীতে উপস্থাপন করা হয়েছে। এছাড়াও উদাহরণ স্বরূপ কয়েকটি গুরুত্বপূর্ণ জলাভূমির সংক্ষিপ্ত বর্ণনাও দেয়া হয়েছে।

বাংলাদেশের জলাভূমিসমূহের শ্রেণীবিন্যাস ও এগুলোর কিছু সাধারন উদাহরণ নিম্নোক্ত ছকে উপস্থাপন করা হলো:

ছক ৮.১: উদাহরণ সহ বাংলাদেশের জলাভূমির ধরন

সিস্টেম (System)	শ্রেনী (Class)	প্রকার (Type) / প্রতীক (Symbol)	জলাভূমি ধরনের নাম (Name of wetland types)	উদাহরণ (Example)
সামুদ্রিক / উপকূলীয় জলাভূমি (Marine/Coastal Wetlands)	স্থায়ী (Permanent)	বিএ (BA)	স্থায়ী অগভীর সামুদ্রিক এলাকা, বেশির ভাগ ক্ষেত্রেই যা নিম্ন জোয়ারের (ভাটা) সময় ছয় মিটারের বেশী গভীরতা অতিক্রম করে না; সমুদ্র-উপকূল (sea bays) ও প্রণালী (straits) এর অন্তর্ভুক্ত।	ছয় মিটার গভীরতা পর্যন্ত সমগ্র উপকূলীয় অঞ্চল
		বিবি (BB)	মেরিন (subtidal) জলজ তলদেশ; কেলপ (kelp) তলদেশ, সমুদ্র-ঘাস তলদেশ, ক্রান্তীয় সামুদ্রিক তৃণভূমি ইত্যাদি এর অন্তর্ভুক্ত।	সমগ্র উপকূলীয় অঞ্চল এবং দ্বীপ সমূহ যা প্লাবিত থাকে এবং যেখানে জলজ উদ্ভিদ জন্মায়।
		বিসি (BC)	প্রবাল প্রাচির (দ্বীপ)	সেন্ট মার্টিন দ্বীপ, কক্সবাজারের কিছু অংশ
		বিএফ (BF)	মোহনাজ (Estuarine) জল; মোহনা এর স্থায়ী জল এবং বদ্বীপ এর মোহনাজ পরিবেশ।	মেঘনা ও কর্ণফুলী নদীর মোহনা, শাহবাজপুর চ্যানেল ইত্যাদি
	অস্থায়ী (Non Permanent)	বিই (BE)	বালি, অমসৃণ নুড়ি বা নুড়ি পাথর; বালির চর, স্পিট (spits) এবং বালুকাময় ক্ষুদ্র দ্বীপ ও সমুদ্র উপকূলের নীচু বালির পাহাড় (dune)এর অন্তর্ভুক্ত;	বঙ্গোপসাগরের সাগর সৈকত।
		বিজি (BG)	জোয়ার-ভাটা অঞ্চলের(Intertidal) কাদা, বালি বা লবণের সমভূমি	টেকনাফ, কক্সবাজার ও অন্যান্য সমুদ্র সৈকত।
		বিআই (BI)	জোয়ার-ভাটা অঞ্চলের (Intertidal) জঙ্গালাকীর্ণ জলাভূমি; ম্যানগ্রোভ জলাভূমি, নিপা (nipah)জলাভূমি এবং জোয়ার-ভাটা অঞ্চলের স্বাদুপানির জলাভূমির বন এর অন্তর্ভুক্ত;	সুন্দরবন
অভ্যন্তরীণ জলাভূমি (Inland Wetlands)	স্থায়ী (Permanent)	বিএল (BL)	স্থায়ী অভ্যন্তরীণ বদ্বীপ	নদীর চর সমূহ
		বিএম (BM)	স্থায়ী (বারমাসি) নদী,জলস্রোত (stream), নালা(খাড়ি); জলপ্রপাত এর অন্তর্ভুক্ত;	বাংলাদেশের স্থায়ী (বারমাসি) নদী, জল-প্রপাত ইত্যাদি।
		বিও (BO)	স্থায়ী (বারমাসি)স্বাদু পানির হ্রদ (আট হেঃএর বড়); বড় বাওর (oxbow lakes) সমূহ এর অন্তর্ভুক্ত;	বিল,বাওর
		বিটিপি (BTP)	স্থায়ী (বারমাসি)স্বাদুপানির জলা/ ডোবা (marshes/pools);পুকুর (আট হেক্টরের নিচে) , জলা ও অজৈব মাটির উপরস্থ জলাভূমি; যেখানে গাছপালার (vegetation) বেড়ে উঠার অধিকাংশ সময় জলাবদ্ধতা থাকে	হাওর-অভ্যন্তরস্থ বিল সমূহ

সিস্টেম (System)	শ্রেনী (Class)	প্রকার (Type) প্রতীক (Symbol)	জলাভূমি ধরনের নাম (Name of wetland types)	উদাহরণ (Example)
		বিএন (BN)	মৌসুমি (seasonal) / সবিরাম (intermittent) / অনিয়মিত (irregular) নদী,জলস্রোত,নালা (খাড়ি)	বাংলাদেশের মৌসুমী নদীসমূহ, পাহাড়ি জলস্রোত (stream), ঝর্ণা ইত্যাদি
		বিপি (BP)	মৌসুমি (seasonal) / সবিরাম (intermittent) স্বাদু পানির হ্রদ (আট হেঃ এর বড়); প্লাবনভূমির হ্রদ এর অন্তর্ভুক্ত;	হাওর ওবিল সমূহ
		বিটিএস (BTS)	মৌসুমি (seasonal) / সবিরাম (intermittent) স্বাদুপানির জলা/ ডোবা (marshes/pools) জলা ও অজৈব মাটির উপরস্থ জলাভূমি; গভীর কাদা পূর্ণ গর্ত (slough), গর্ত (pot-hole), মৌসুমী প্লাবিত তৃণভূমি (medows), নলখাগড়া জাতীয় তৃণ জন্মায় এমন জলাভূমি এর অন্তর্ভুক্ত;	হাওর এলাকার অভ্যন্তরের নিচুএলাকা/গর্ত ইত্যাদি
		বিইউ (BU)	অ-জঙ্গালাকীর্ণ পিট ভূমি (peat land); গুল্ম পূর্ন (shrub)এলাকা বা উন্মুক্ত পন্কিল জলা (bog), জলাভূমি (swamp) ও জলা (fen) এর অন্তর্ভুক্ত;	হাওর এলাকার অভ্যন্তরে এবং সাতক্ষীরা, খুলনা ও গোপালগঞ্জের বিল এলাকায় কিছু পিট ভূমি রয়েছে
		বিডব্লিউ (BW)	অধিক গুল্ম (shrub)অধ্যুষিত জলাভূমি; গুল্ম জলাভূমি(swamp), অধিক গুল্ম-অধ্যুষিত স্বাদুপানির জলা (marsh), গুল্ম ঝোপ (carr), অজৈব মাটির এলডার (Alder) গাছের ঝাড়	হাওর/বিল এলাকার মধ্যে পাওয়া যায়
		বিএক্সএফ (BXF)	অধিক গাছ অধ্যুষিত জলাভূমি; স্বাদুপানির জলা (swamp)বন, মৌসুমী প্লাবিত বন, অজৈব মাটির বৃক্ষাচ্ছাদিত জলাভূমি (swamp)	হাওর এলাকার মধ্যে পাওয়া যায়
		বিএক্সপি (BXP)	পিট ভূমির (peat land) বন;পিট জলাভূমির (peat swamp) বন;	সাতক্ষীরা, খুলনা ও গোপালগঞ্জের (নিম্নাঞ্চলের) পিট ভূমির বন

সিস্টেম (System)	শ্রেনী (Class)	প্রকার (Type) প্রতীক (Symbol)	জলাভূমি ধরনের নাম (Name of wetland types)	উদাহরণ (Example)
মানব সৃষ্ট জলাভূমি (Human-made Wetlands)	স্থায়ী (Permanent)	বি ১ (B1)	মৎসচাষ (মাছ/চিংড়িচাষের পুকুর)	দীঘি, পুকুর, চিংড়ি চাষের পুকুর
		বি ২ (B2)	পুকুর;খামার পুকুর, স্টক(মাছের পোনা প্রতিপালনের) পুকুর, ছোট পুকুর (সাধারণত আট হেক্টরের ছোট) এর অন্তর্ভুক্ত;	ছোট পুকুর,মাছ চাষের ছোট পুকুর
		বি ৬ (B6)	পানি জমিয়ে রাখা বা সংরক্ষনের জায়গা ; জলাধার / ব্যারেজ / ড্যাম / পানি সংরক্ষনের জায়গা (impoundments) (সাধারণত আট হেক্টরের অধিক)	তিস্তাব্যারেজের জলাধার, কাপ্তাই হ্রদ, মুহুরি ও মাগুরা ব্যারেজ/ ড্যামের জলাধার ইত্যাদি
		বি ৮ (B8)	বর্জ্য পানি শোধন এলাকা; নর্দমার আবর্জনার খামার, (শোধনাগারের) থিতানোর (settling) পুকুর, অক্সিডেশন বেসিন (oxidation basins) ইত্যাদি	পাগলায় অবস্থিত ঢাকাওয়াসা এর বর্জ্য পানি শোধনাগার
		বি৯ (B9)	খাল (Canal) ও নিষ্কাশন খাল, পরিখা/নালা (ditch)	মাদারিপুর বিল রুট, বাপাউবো এর তিস্তা ওঅন্যান্য প্রকল্পের সেচ ও নিষ্কাশন খাল ইত্যাদি
	অস্থায়ী (Non Permanent)	বি ৩ (B3)	সেচের জমি;সেচ খাল ,ধান খেত এর অন্তর্ভুক্ত;	বাপাউবো এর সেচ প্রকল্প এলাকা সমূহ
		বি ৪ (B4)	মৌসুমী প্লাবিত কৃষি জমি (নিবিড়ভাবে পরিচালিত বা ব্যবহৃত চারণ ভূমি বা ভিজা তৃণভূমি এর অন্তর্ভুক্ত);	নদীর প্লাবন ভূমি
		বি ৫ (B5)	লবণ আরোহন এলাকা; লবণ চাষ এলাকা (salt pan), লবনাক্ত এলাকা ইত্যাদি	টেকনাফ, বরিশাল ইত্যাদি উপকূলীয় অঞ্চলের লবনাক্ত এলাকা ও লবণ আরহন এলাকা
		বি ৭ (B7)	খনন কাজ: নুড়ি / ইট তৈরির / মাটি ইত্যাদি সংগ্রহের গর্ত, রাস্তার পাশের গর্ত বা নালা,খনির পুল বা গর্ত	রাস্তার পাশের গর্ত বা নালা,বড় পুকুরিয়া কয়লা খনির খনন কৃত গর্ত ইত্যাদি

সিস্টেম (System)	শ্রেনী (Class)	প্রকার (Type) প্রতীক (Symbol)	জলাভূমি ধরনের নাম (Name of wetland types)	উদাহরণ (Example)
পূর্বর্তী অবস্থায় ফেরৎ যোগ্য/ রিভার্সিবল জলাভূমি (Reversible Wetlands)		বিআরভিসি (Brvc)	উপকূলবর্তী পোল্ডার ও অন্যান্যবাঁধ (embankment)	দেশের 139 টি উপকূলীয় পোল্ডার;
		বিআরভিআই (Brvi)	(অভ্যন্তরিণ) বন্যা নিয়ন্ত্রন ও নিষ্কাশন (FCD) এবং বন্যা নিয়ন্ত্রন,নিষ্কাশন ও সেচ (FCDI) প্রকল্প; বাঁধ (embankment)দ্বারা বেষ্টিতবন্যা মুক্ত অন্চল	বাপাউবো এর সকল অভ্যন্তরিন বন্যা নিয়ন্ত্রন ও নিষ্কাশন (FCD) এবং বন্যানিয়ন্ত্রন,নিষ্কাশন ও সেচ (FCDI) প্রকল্পসমূহ
		বিআরভিই (Brve)	পরিবেশগতভাবে অবনমিত (environmentally degraded) , কিন্তু পূনরুদ্ধার যোগ্য জলা ভূমি; দূষিত নদী, দখলকৃত নদী, খাল, নিম্ন ভূমি ইত্যাদি এর অন্তর্ভুক্ত;	দূষিত নদী, দখলকৃত নদী,খাল, নিম্নভূমি ইত্যাদি

নোট: (BX) বি-দিয়ে বাংলাদেশ বুঝায়; এক্স-দিয়ে রামসার শ্রেণী বিন্যাসের এক্স টাইপকে বোঝায়।

নোট: বিআরভি/সি/আই/ই দ্বারা যথাক্রমে বাংলাদেশ রিভার্সিবল উপকূলীয়/অভ্যন্তরীণ/প্রতিবেশগত জলাভূমি বোঝায়।

বাংলাদেশের জলাভূমি সমূহের শ্রেণীবিন্যাসটি সমগ্র বাংলাদেশ ব্যাপি বিস্তৃত ভৌগলিক এলাকার বিভিন্ন স্বতন্ত্র ব্যক্তি ও সংস্থার বহুবিধ অভীষ্ট লক্ষ্য অর্জন ও ব্যবহারের জন্য প্রণয়ন করা হয়েছে। এই সমীক্ষার প্রধান সুপারিশসমূহ নিম্নে বর্ণিত হলো:-

(১) সমগ্র বাংলাদেশে একক জাতীয় পদ্ধতি হিসেবে এই শ্রেণীবিন্যাস পদ্ধতি ব্যবহার করা উচিত।

(২) বাংলাদেশ সরকার কর্তৃক এই শ্রেণীবিন্যাস পদ্ধতিটি অনুমোদন এবং সমগ্র বাংলাদেশে স্বতন্ত্র ব্যক্তি ও সংস্থা কর্তৃক এটি ব্যবহারের লক্ষ্যে নির্দেশনা জারি করার জন্য জোরালো সুপারিশ করা যাচ্ছে।

(৩) জলাভূমি সম্পর্কিত যেকোন নূতন বর্ণনা /তথ্যাদি হালনাগাদ, পরিমার্জন কিংবা সংশো ধন ইত্যাদি বাংলাদেশের জলাভূমির শ্রেণীবিন্যাসের সাথে সামঞ্জস্যপূর্ণ হতে হবে।

(৪) প্রত্যেক প্রকার (type) জলাভূমির জন্য মাইক্রো লেভেল তালিকা (Inventory) সম্পর্কিত গবেষণা (study) কার্যক্রম গ্রহণ করা উচিত।

(৫) এ জাতীয় গবেষণা (study) পরিচালনা করার জন্য সূক্ষ রেজোলুশনের স্যাটেলাইট চিত্র সংগ্রহ করা যেতে পারে। বাংলাদেশ হাওর ও জলাভূমি উন্নয়ন অধিদপ্তর কর্তৃক অবিলম্বে বর্ষা ও শুষ্ক উভয় মৌসুমের স্যাটেলাইট চিত্র/ইমেজ সংগ্রহ করার লক্ষ্যে প্রকল্প গ্রহণের শুরুর উদ্যোগ গ্রহণ করা উচিত।

(৬) জলাভূমির (প্রকার/টাইপভিত্তিক) প্রতিবেশ সংক্রান্ত বৈশিষ্ট্যের (ecological characteristics) উপর সমীক্ষা কার্যক্রম শুরু করা উচিত।

(৭) বাংলাদেশ হাওর ও জলাভূমি উন্নয়ন অধিদপ্তর কর্তৃক জলাভূমি সমূহের শ্রেণীবিন্যাসের উপর ভিডিও ডকুমেন্টরী তৈরির উদ্যোগ নেয়া উচিত।